

NATIONAL BUREAU OF STANDARDS REPORT

10 237

U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

First U. S. Team Visit
November 1969



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT

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U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

First U. S. Team Visit
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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

ABSTRACT

The observations of the first U.S. Team to visit France as part of the U.S./French Cooperative Program on Building Technology are reported. The five man team from the Building Research Division of the National Bureau of Standards, U.S. Department of Commerce, was in France November 16 through November 29. Topics covered and reported by the first team are:

1. Economic Appraisal in Buildings
2. Assessing the Quality of Buildings
3. Agrément System and Full-Scale Testing
4. Advancement of Applied Building Science
5. Industrialized Buildings
6. Soils and Foundations
7. Plumbing Systems and Research
8. U.S./French Program Coordination

An evaluation of the cooperative program as well as possible future study topics and joint research projects are reported.

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1. INTRODUCTION

1.1 Background

President Nixon of the United States and former President de Gaulle of France met in Paris during the spring of 1969 to discuss the relationship between their countries. During the course of these talks they expressed the desire to renew scientific and technical cooperation between the countries. As a result of these talks Ambassador Sargent Shriver (U.S. Embassy in France) sent Dr. Edward D. Piret (Chief, Scientific Affairs of the U.S. Embassy in France) to the U.S. to explore possibilities of cooperation.

The National Bureau of Standards was one of several agencies visited by Dr. Piret in early April. With the approval of Dr. Allen V. Astin, former NBS Director, Dr. Piret spoke with several persons in the Bureau. Among the persons contacted was Dr. James R. Wright, Chief of the Building Research Division. During their conversation it was discovered that both men knew Dr. Gerard Blachere, the director of the Centre Scientifique et Technique du Batiment (CSTB), of France. In this country NBS is close to CSTB in terms of its laboratory facilities and federal mandate (although CSTB is stronger in one sense because it has the authority to enforce the French building code).

It became apparent that a cooperative program between the Building Research Division (and possibly HUD) and the CSTB might be useful, since in the course of their work the heads of these two groups had already met on common grounds. Dr. Wright subsequently submitted to Dr. Piret a list of possible interest areas for the Building Research Division. The following persons then met in Paris on May 19 to discuss topics appropriate for a U.S./French Cooperative Program on Building Technology.

- a. Dr. James R. Wright, Chief, Building Research Division, NBS
- b. Dr. George Snowden, Director for International Activities, HUD
- c. Dr. Edward Piret, Chief, Scientific Affairs of the U.S. Embassy in France
- d. Dr. Gerard Blachere, Director, CSTB
- e. M. Charles Noel, Deputy Director, CSTB

Both study topics and funding methods were discussed.

Dr. Wright met with Dr. Oswald H. Ganley and Mr. Richard W. Baker, both Department of State, SCI, at the National Bureau of Standards on May 28 to discuss U.S./French cooperation and Dr. Wright's May 19 meeting in Paris. At this meeting it was decided to:

1. Obtain Department of State approval for cooperation in principle.
2. Obtain approval of participating U.S. institutions.
 - a. NBS (Dr. Allen V. Astin)
 - b. HUD (Dr. Harold B. Finger)
3. Select a U.S. technical team to conduct further discussions of cooperative areas.

4. Exchange visits between U.S. and French technical teams. The team tasks would be:
 - a. Identification of specific programs
 - b. Emphasis on projects with potential cost- and time-saving results
 - c. Identification of opportunities for exchanges of guest workers
 - d. Identification of additional French institutions with which cooperation could be arranged through CSTB on given projects
5. Continuing follow-up
 - a. Contacts between individuals
 - b. Carving out of agreed programs
 - c. Exchange of guest workers
 - d. Selection of new projects as initial projects are concluded
 - e. Agreements, (contractual arrangement) wherever desirable

At this meeting Dr. Wright expressed the feeling that NBS could serve as the contact point for other U.S. participation, including HUD, as well as private industry. Dr. Wright also stated that the possibilities for increased cooperation are the greatest in areas where one side is just getting started and the other has been active for some time. Cooperation could be in the form of exchange of guest workers. At this meeting, Dr. Wright also stressed that management level explorations had gone as far as possible and that technical people would have to examine specific topics. He proposed that teams of about five men be exchanged for two to three weeks.

On June 5, 1969, Dr. Wright met with Dr. Morris Levy, Chief of the French Scientific Mission in the U.S., Mr. A. Poree,

Attache of the Mission, and Dr. Blachere, Director of CSTB, in Washington. The following resulted from that meeting:

1. NBS and CSTB would not limit their efforts only to each other, but would channel interests and efforts to other institutes in their countries.
2. Contact would be made directly between NBS and CSTB under the guidance of a general organization to be created in a diplomatic way.
3. NBS and CSTB should confirm areas of interest.
4. Teams should be exchanged, tentative dates for latter 1969 were set.

The U.S. Office of Science and Technology in Washington released a statement July 29 concerning U.S./French Scientific and Technical Cooperation. It was announced that F.X. Ortoli, Minister of Industrial Development and Scientific Research of France would meet with Dr. Lee A. DuBridge, Scientific Advisor to the President of the U.S. in Paris in late September to discuss new areas and review present areas of cooperation. They would also discuss flexible procedures to allow expanded cooperation as well as steady and timely progress. It was further announced that some agencies were already in contact with each other to discuss cooperation.

Dr. Wright, Dr. Blachere, and Dr. Piret met in Paris September 18 and 19, while attending a CIB Conference on Building Performance, and had further discussion.

Details for the U.S. Team visit were completed in early October. The U.S. Team was scheduled to arrive in Paris on Sunday, November 16 and depart on Saturday, November 29. The schedule allowed ten working days to carry out the studies on building technology.

The study program was broken down as follows:

<u>Topics</u>	<u>Total Man Days</u>	<u>Number of Individuals Participating</u>
1 Economic appraisal in buildings	2	1
2 Assessing the quality of buildings	5	1
3 Agrément system and full-scale testing	13	2
4 Advancement of applied Building sciences (psychological and social)	5	1
5 Industrialized buildings	16	4
6 Soils and foundations	5	1
7 Plumbing systems and research	1	1
8 U.S./French program coordination	3	1

Brief descriptions of topics 1 through 7 are contained in Appendix A. Topics 1 through 5 were proposed in the early talks. Topics 6 and 7 were added in the final planning stages.

The NBS team was made up of the following members of the Building Research Division staff:

	<u>Position</u>	<u>Professional Discipline</u>
Mr. H.E. Thonpson*	Deputy Chief, Building Research Division	Architect - Engineer
Mr. V.E. Gray	Assistant Chief, Materials Durability and Analysis Section	Research Chemist
Mr. T.E. Ware	Assistant Chief, Building Systems Section	Architect
Dr. A.I. Rubin	Research Psychologist, Psychophysics Section	Research Psychologist
Dr. E.V. Leyendecker	Structural Research Engineer, Structures Section	Structural Research Engineer

*Head, NBS Team on Building Technology

The Department of Housing and Urban Development was interested in the cooperative program, but was unable to participate since most of its personnel were occupied with Operation Breakthrough.

The original breakdown of time is shown below:

Team Time (Man Days)	<u>TOPIC</u>							
	1	2	3	4	5	6	7	8
Mr. H.E. Thompson	2				4		1	3
Mr. V.E. Gray			10					
Mr. T.E. Ware		5			5			
Dr. A.I. Rubin				5	5			
Dr. E.V. Leyendecker			3		2	5		
TOTAL MAN DAYS	2	5	13	5	16	5	1	3

The actual time spent on each topic varied from that shown above according to team member's judgement in Paris. The actual times are summarized in section 1.3 and a detailed breakdown is shown in section 1.4.

While the U.S. team was in France it was announced that three distinguished scientists and administrators had been designated to provide high-level coordination for an expanded program of scientific and technical cooperation between the U.S. and France. Dr. Allen V. Astin, former NBS Director was appointed as the U.S. representative. Mr. Pierre Laurent, Director General for Cultural and Scientific Relations and Technical Assistance for Development at the Foreign Ministry, and Dr. Pierre Aigram, Delegate-General for Scientific and

Technological Research, were appointed as the French representatives. The purpose of the group is to provide a channel for continuing liaison, to establish a flow of information on status and development of cooperative arrangements, and to search for new scientific and technical areas of mutual interest.

1.2 Objective

1.2.1 Objective of Cooperative Program

The objective of the U.S./French cooperative Program is to encourage scientific cooperation between the U.S. and France. Such cooperation will allow both countries to move forward with significant research and development without costly, time-consuming duplication of effort in each country.

1.2.2 Objectives of First U.S. Team

The objectives of the first U.S. team were to:

- a. Conduct in-depth evaluation of the selected topics for obtaining information that would be useful to U.S. research and the possible assignment of U.S. guest workers.
- b. Examine other areas of cooperation to determine specific projects as well as the extent of possible cost savings in an exchange. (Selection of topics for other five-man teams).
- c. Work out details for the first French team visit to the U.S. in 1970.

1.3 Team Members and Topics

The actual time spent on each of the selected topics and the professionals involved in each topic are listed below:

TOPICS	TOTAL MAN DAYS	PROFESSIONAL
1. Economic appraisal in buildings	2 1/2	Thompson
2. Assessing the quality of buildings	5	Ware and Rubin
3. Agrément system and full-scale testing	10	Gray and Leyendecker
4. Advancement of applied building Science. (Psychological and Social)	6	Rubin and Ware
5. Industrialized buildings	7	Thompson, Ware Rubin, & Leyendecker
6. Soils and foundations	4	Leyendecker
7. Plumbing systems and research	1	Thompson
8. U.S./French Program Coordination	2	Thompson
CSTB briefings	5	Entire Team
CEBTP laboratory tour	3	Thompson, Gray & Leyendecker

1.4 Itinerary

1.4.1 General

The U.S. team arrived in Paris on Sunday, November 16

and was met at the airport by a CSTB representative (Mr. G. Hierholtz) who took them to the hotel. That afternoon the team was given the itinerary for the five members.

The overall schedule for the team is shown in figure 1.1. Detailed description of the time and persons involved with each topic follows in section 1.4.2.

In addition to serving as the host on most of the topics, CSTB personnel hosted a dinner on November 21 and a cocktail party on November 28 for the team members. The team left Paris on Saturday, November 29.

1.4.2 Detailed Description of Itinerary

X CSTB BRIEFINGS

Monday, November 17

- | | | |
|-------------|---|---|
| Entire Team | - | <u>CSTB: 4 avenue du Recteur Poincare, Paris 16e</u>
1. Informal meeting of NBS team with all concerned with visit
2. Presentation of the general background for the proposed programs
3. Presentation of the role of CSTB |
| | - | <u>CSTB Research Station, Champs sur Marne</u>
1. Organization and layout of the station
2. General visit |

Figure 1.1 U.S. ITINERARY

U.S./French Cooperative Program in Building Technology

First U.S. Team Visit to France: November 16 - November 29, 1969

NAME	First Week							Second Week							X: CSTB Briefings XX: Other Briefings
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
H. Thompson	--	X	1	1	1/8	8/**	--	--	5	5	*	7	8	--	1. Economic Appraisal in Buildings
V. Gray	--	X	3	3	3	3	--	--	3	3	*	3	3	--	2. Assessing the Quality of Buildings
T. Ware	--	X	2	2	2	4	--	--	5	4	XX	5	2	--	3. Agreement System and Full-Scale Testing
A. Rubin	--	X	2	2	4	4	--	--	4	4	XX	5	XX	--	4. Advancement of Applied Building Science (Psychological and Social)
E. Leyendecker	--	X	6	6	6	6	--	--	5	5	*	3	3	--	5. Industrialized Buildings
															6. Soils and Foundations
															7. Plumbing Systems and Research
															8. Coordination
															* General visit to CEBTP Laboratory
															** Batimat

1. ECONOMIC APPRAISAL OF BUILDINGS

Tuesday, November 18

Mr. H.E. Thompson - Paris, CSTB Office

1. French Conventional methods describing building evaluating quantities, and setting up prices (Mr. Noel and Mr. Duc)
2. The quality and price combination (Mr. Noel and Mr. Duc)
3. The ARC method to evaluate and analyze quantities (Mr. Noel and Mr. Hunt)

Wednesday, November 19

Mr. H.E. Thompson - Paris, CSTB Office

1. ARC information (Mr. Hunt, Sultana, and Chatelien)
2. Omnium Technique de l'Habitation (OTH)
18, boulevard de la Bastille, Paris 12e

Presentation of the OTH evaluation department (Mr. Noel)

Thursday, November 20

Mr. H.E. Thompson - Paris, CSTB Office

1. Systematic method to describe buildings (Mr. Noel and Duc)
2. Tentative approach to the right price depending on certain parameters. (Mr. Noel and Mr. Duc)

2. ASSESSING THE QUALITY OF BUILDINGS

Tuesday, November 18

Mr. T.E. Ware - Paris, CSTB Office

Dr. A.I. Rubin 1. Building concept and scientific methods (Mr. Cami)

2. Definition based on needs (Mr. Cami)
3. The synopsis (Mr. Cami)

Wednesday, November 19

Mr. T.E. Ware -
Dr. A.I. Rubin

Paris, CSTB Office

1. French conventional methods
describing evaluating quantities,
setting up prices (Mr. Noel and Duc)
2. The quality and price combination
(Mr. Noel and Duc)

Mr. T.E. Ware
(with Mr. Cami)

Marseille (by airplane)

1. Presentation of research about
a methodology for architectural
creation (Mr. Poux)
2. Presentation of CIAB activities
(Mr. Quintrand)

Thursday, November 20

Mr. T.E. Ware

Marseille

1. Visit Languedoc-Roussillon and
FOS operations (Mr. Cami)
2. Return to Paris (Mr. Cami)

Friday, November 28

Mr. T.E. Ware

Paris

Omnium Technique de l'Habitation (OTH)

3. AGREEMENT AND FULL-SCALE TESTING

Tuesday, November 18

Mr. V.E. Gray

- Paris, CSTB Office

The Agreement-General-UEATC (Mr. Chabrel)

Wednesday, November 19

Mr. V.E. Gray - Champs sur Marne, CSTB Research Station
New concrete or gypsum materials
(Mr. Chabrel)

Thursday, November 20

Mr. V.E. Gray - Champs sur Marne, CSTB Research Station
Floorings, UPEC classification
(Mr. Farhi)

Friday, November 21

Mr. V.E. Gray - Champs sur Marne, CSTB Research Station
1. Wall Facings (Mr. Farhi)
2. Mastic Compounds (Mr. Farhi)
3. Waterproofing (Mr. Farhi)

Monday, November 24

Mr. V.E. Gray - Paris, CSTB Office
1. Light facades-EdR K Classification
(Mr. Berthier)
2. Light partitions (Mr. Berthier)

Tuesday, November 25

Mr. V.E. Gray - Champs sur Marne, CSTB Research Station
1. Windows (Mr. Berthier)
2. Light Structure houses (Mr. Berthier)

Thursday, November 27

Mr. V.E. Gray - Paris, CSTB Office
Dr. E.V. Leyendecker
1. Heavy facade (Mr. Lugez)
2. Floors (Mr. Mathez)

Friday, November 28

Mr. V.E. Gray - Paris, CSTB Office
Dr. E.V. Leyendecker
1. Non conventional structures
(Mr. Lugez)
2. Stability (Mr. Lugez)

4. ADVANCEMENT OF APPLIED BUILDING SCIENCE

Thursday, November 20

Dr. A.I. Rubin - Saint Remy les Chevreuse UTI laboratories
(with Mr. Josse)

1. Acoustics Laboratory
2. Discussion about the way to obtain acoustically satisfying buildings
3. Thermics laboratory (Mr. Croiset)

Friday, November 21

Dr. A.I. Rubin - Paris, CSTB Office
Mr. T.E. Ware

1. Acoustics (Mr. Josse)
2. Psycho-sociology (Dr. Chabrier)
3. Visit work site, heating and ventilating (Mr. Croiset)

Monday, November 24

Dr. A.I. Rubin - Champs sur Marne, CSTB Research Station

1. Thermal and ventilating research (Mr. Croiset)
2. Acoustics (Mr. Josse)
3. Traffic noises (Mr. Aubrei)
4. Lighting (Mr. Dourgnon)
5. Space Perception (Dr. Chabrier)

Tuesday, November 25

Dr. A.I. Rubin - Paris, CSTB Office
Mr. T.E. Ware

1. How thermal quality is obtained in social housing (Mr. Croiset)
2. Visit of social housing sites (heating)

5. INDUSTRIALIZED BUILDINGS

Monday, November 24

Mr. H.E. Thompson - Tourville - (Option System)

Mr. T.E. Ware
Dr. E.V. Leyendecker
(with Mr. Hierholtz)

"Mecanno" type system using BARETS technique. Cooperative plant making prefab concrete components for a group of contractors (30), architects, engineering office.
Visit of the plant and a site of single family houses (HLM category)

- ROUEN - (GEAI System)

Groups of 5 story apartment buildings (500 dwellings) in a large estate (HLM) Corten steel skeleton, Prefab steel floors. Aluminium framed sliding windows. Resin concrete flooring. Dry partitions (FONTEX). Forced air heating.

Tuesday, November 25

Mr. H.E. Thompson
Dr. E.V. Leyendecker
(with Mr. Heirholtz
and General Dupont)

- Sartrouville - (OUTINORD System):

Cast-in-place concrete, using twin inverted L forms.
5 Story apartment buildings (HLM)
(700 dwellings)

- Acheres - (GLD System):

Cast-in-place concrete, using lengthwise rolling tunnel forms. Facade walls made of special lime-stone powder concrete. Several 5 story apartment buildings (140 dwellings) (HLM).

- Ezanville - (TRACOPA I System):

Totally prefab buildings, made with large concrete panels (496 dwellings)

Cavity gypsum partitions made on site. 5 story apartment buildings (HLM)

- Persan - (SAE plant):

A plant producing concrete components of many kinds and ceramic concrete large panels. A model of prefabricated concrete single-family house.

- Sarcelles -

Short sightseeing tour of this new town (1,600 apartments)

Thursday, November 27

Mr. T.E. Ware
Dr. A.I. Rubin
(with Mr. Heirholtz)

- Massy Antony

Sightseeing tour of this new town (9,400 apartments HLM)

- Sainte Genevieve Des Bois: VILLAGEXPO:

Once Exhibition, now inhabited high density district of (187) single-family houses made with 22 different systems.

- Sainte Genevieve Des Bois (BOUYGUES System)

Cast-in-place concrete multistory buildings with prefabricated concrete facade panels with rounded edges.

- La Grande Borne - (OUTINORD System)
(BOUYGUES System)

Large estate five story building (3780 dwellings). Rectangular or winding horizontal lay out (HLM)

Cast-in-place concrete cross walls. prefabricated concrete facade panels.

- Grigny 2 -

Starting of a semi-luxurious large estate. Multistory buildings just beginning (OUTINORD). Model apartments, financing example.

- Hameaux De La Roche (Ris-Orangis)

Many single-family houses of the same model (set back one from another along winding lines)

- L'Oree De Senart (Draveil):

A semi-luxurious estate with multi-story apartment buildings scattered in a park. Made of large prefabricated ceramic concrete panels.

- Vigneux (TRACOPA I system)

Several tall apartment buildings (HLM) (24 story) made of large prefabricated concrete panels.

- Villeneuve Le Roy (BALENCY plant)

Semi-fixed prefabrication plant for multistory buildings (batteries feed through a concrete pump and tilting tables) and for single-family houses (Plant with opening roofs).

6. SOILS AND FOUNDATIONS

Tuesday, November 18

Dr. E.V. Leyendecker - Paris, Saint-Germain underground parking lot (under construction). Visit to a construction site using the technique of parois-moulees (a special type of "cast-in-place wall" before excavation) (Mr. Guitten, engineer in charge of construction and Mr. Rico, LCPC)

Wednesday, November 19

Dr. E.V. Leyendecker - Paris, CEBTP laboratory, 12 rue Brancion
Discussion and tour (Mr. Lebeque)

- Saint Remy les Chevreuse, CEBTP laboratory
Discussion and tour of soils and foundations facilities (Dr. Tchong)

Thursday, November 20

- Dr. E.V. Leyendecker - Puteaux, Bureau d'Etudes de la Terre Armee
Discussion of reinforced earth, a new principle of embankment design (Mr. Godet and Mr. Vidal, originator)
- Boulogne Billancourt, 66 route de la Reine
Discussion at office of Europe-'Etudes and visit of a building under construction (Mr. Fuzier)

Friday, November 21

- Dr. E.V. Leyendecker - Paris, Laboratoire Central des Ponts et chaussees (LCPC), 58 boulevard Lefebvre
Discussion of LCPC and tour of laboratory (Mr. Rico, Mr. Pilot, and Mr. Schlosser)

7. PLUMBING SYSTEMS AND RESEARCH

Thursday, November 27

- Mr. H.E. Thompson - Champs sur Marne, CSTB Research Station
- | | |
|------------------------------|-------------------|
| 1. General | (Mr. Chargrassse) |
| 2. Sanitary appliances tests | (Mr. Chargrassse) |
| 3. Tap tests | (Mr. Chargrassse) |
| 4. Tube tests | (Mr. Chargrassse) |
| 5. Hydraulics in buildings | (Mr. Chargrassse) |

8. COORDINATION

Thursday, November 20

- Mr. H.E. Thompson - Paris, CSTB Office
Discuss U.S./French Program with G. Blachere

Friday, November 21

- Mr. H.E. Thompson - Paris, CSTB Office
Discuss U.S./French Program with G. Blachere

Friday, November 28

Mr. H.E. Thompson - Paris, CSTB Office
Discuss U.S./French Program with
G. Blachere

* CENTRE EXPERIMENTAL DE RECHERCHES ET D'ETUDES DU BATIMENT
et des travaux Publics (CEBTP)

Wednesday, November 26

Mr. H.E. Thompson - Paris
Mr. V.E. Gray
Dr. E.V. Leyendecker 1. Tour of CEBTP laboratory
2. Discussion with Dr. l'Hermite and
Mr. Fickelson

Saint Remy les Chevreuse

Tour of CEBTP laboratory
(Mr. Fickelson and Mr. Bresson)

** MISCELLANEOUS

Friday, November 21

Mr. H.E. Thompson - La Defense: new district. Tall office
and apartment building. Complex
transportation net work. Large central
heating and cooling plant. Large
concrete triangular Exhibition hall.

- BATIMAT exhibition (building components
and equipment)

2. TEAM MEMBERS' REPORTS

2.1 General

A joint meeting was attended by all NBS team members the first day of the visit. The team was received at the CSTB headquarters conference room by Dr. Gerard Blachere. A number of other representatives from CSTB and the construction industry in France were also present. During the meeting Dr. Blachere discussed the French construction industry and CSTB (its programs and missions).

The CSTB headquarters is located in downtown Paris which handles all of the administrative part of their activities. The main CSTB laboratories are presently located in the eastern suburbs of Paris at Champs sur Marne. Two other annexes are located at Grenoble and Nantes.

The annex at Nantes will handle wind studies on buildings, lighting, social sciences, and rain penetration. The annex at Grenoble will accommodate laboratory functions on the aging of materials, physics and building acoustics, and acoustics in relationship to sonic booms.

Dr. Blachere in his discussion on the construction programs in France indicated that they have one performance-type building code. However, they no longer like the word performance in France, instead they prefer to use "physical requirements". The code is very short (only about an inch thick) with some two pages per section. The code is handled

through the local organizations in the local community. CSTB develops the code requirements, then the Ministry acts with legislation to get the requirements into law.

The population of France is approximately 50,000,000 people. About 420,000 dwellings are being produced a year. 300,000 of these are social housing; 200,000 are called flats or nonpublic type dwellings. CSTB assists in giving aid to the social housing program similar to the U. S. housing program. The CSTB staff is quite concerned with future social housing because the salaries of French workers have not kept up with the housing costs so there is a large subsidy that the French government has to provide. They also have to consider cheap housing, because of the low income people. Because of their low salaries, CSTB is trying to accommodate them with cheaper kinds of housing.

The architect and the contractor are responsible for the quality and stability of their buildings for ten years. This responsibility is reflected in insurance costs which are based only on a percentage of the labor costs of the building. It does not include the total cost or the material cost. Since insurance companies are so involved they can regulate the insurance rates for better quality. They also approve the design and construction plans as well as approve the construction, in accordance with the insurance requirements. This is called the Bureaux de Controle.

There are several hundred firms who are general contractors in France. They have the Bureau de Etude (BET). This is an organization that has developed managerial and contractual operations of the construction process that is developed during the beginning of the design and they are considered as specialists on the construction process.

CSTB also assists the various ministries in the French construction programs. These include school programs, health facilities, and also some work with the war department. They also work with the central committee of public contract.

Unlike the United States which has separate unions for each construction trade, France has one union for all construction work. This permits them to work freer than we can and it would be an advantage if the U. S. also had the same set up. In the industrialized building process there is a need for a large percentage of unskilled labor on the building site. The contractors use a lot of foreign workers to fill this need. There are some 500,000 people involved in unskilled labor. Most of these come from Spain, Turkey, and various countries where cheap labor is available.

In France there are public research centers. These centers are semi-public organizations that are linked to the various professions. They are also linked to general contractors as an industry and to the materials producers. A tax advantage is available to the general contractors or

materials producers if they do their own research when there are no private laboratories available. In France, as in the United States, these public research centers and CSTB are not all working under a coordinated program, which would be to an advantage to France as well as to any other country.

Dr. Blachere also mentioned the five year programs that Dr. Levy (French Embassy) had mentioned to the U. S. Team in a prior meeting. They are now working on the sixth five year plan for the nation on housing. Building research is one of the major areas that is included in the French program. Therefore, CSTB is developing their planning in relationship to this five year program. There is a government agency for technology and research which handles the program matter and funds given to CSTB.

Dr. Blachere described the programs and activities of CSTB as:

- (1) Advising the ministry regarding regulations and special projects;
- (2) The building profession in general developing standards, methods of construction, modes of research, and equipment methods;
- (3) The Agrément System. (Dr. Blachere would like to rename this Technical Advice in lieu of Agrément.) This is on new materials and new systems processes. CSTB receives the application report from the Housing

Agency and they give final advice back on their approval for evaluation of the system;

- (4) Basic research. This basic research is on Agreement needs or user needs.
- (5) Publications and teachings. CSTB produces reports that are included in their printed standards (R.E.E.F.'s). This is standards information that they provide to designers. The publication also involves codes and standards and Agreement. Teaching activity is limited but CSTB has teams that do teach in some of the architectural and engineering schools. Dr. Blachere indicated that the professional schooling of the professional architectural and engineers is very limited and is not as extensive as in the United States.

At the conclusion of Dr. Blachere's discussion some additional points of interest were covered. He mentioned that they have a competition for a package design and construction that is used more on some of their large public buildings or social housing projects. The architect and contractor submit their proposals. The one that wins the competition is given the design and construction contract based on the price that he has submitted. This competition method permits the government to consider various alternatives and also permits them to negotiate back and forth on some of the details

regarding the design and the construction.

In the afternoon the team had lunch and visited the CSTB research station east of Paris at Champs sur Marne. These laboratories are broken down into three different areas -called (1) human requirements, (2) sciences, and (3) application sciences. Human requirements include lighting and thermal comfort. The sciences include acoustics, thermal, materials, fire, plumbing, insulation, rain penetration, and structures (only regarding prefabricated structures) on industrialized building processes in relationship to the Agreement Systems. They do develop new materials at times.

The programs in relationship to what they call applications includes the Agreement and standardization. Standardization is the relationship to gypsum partitions, joinery, lightweight panels, flooring and wall coverings, plastics, and equipment which is primarily mechanical not electrical. Also of interest in relationship to the laboratories, industry is just completing research facilities adjacent to the CSTB. The industry laboratory will primarily study windows and doors rather than structural systems. Apparently other industries will move into other adjacent areas in the near future; however, no construction has yet started.

Some five years ago, the Ministry pushed CSTB to develop

some open systems in lightweight exterior wall panels which were erected and completed at the CSTB site. These were to be used for buyers to come and select wall panels for social housing. These included competition among six applications, or six panels. The program did not prove successful and was never utilized. However, the panels are still on exhibit at the site.

In the social housing construction program, CSTB is still very active in what they consider four different types of housing construction methods. First is biton banche which is pressurized concrete used at the building site. Second is prefabricated wall panels. Prefabricated wall panels are broken down into four types--sandwich type with insulation in the middle; brick panels with brick panels in the middle; homogeneous which includes lightweight concrete; and thin shells of vibrated concrete with insulation poured in between the two thin shell panels. The other construction methods in housing involve light weight facades and neccano. This includes joinery, which are in-filled light weight sheets (may be filled with glass or plywood). Lightweight sheets will be either plywood or steel. They also have stamped panels with insulation which are aluminum or steel.

The trip around the laboratories was very fast and the reports on the other topics provide information on the various types of laboratory facilities. The larger facilities that show more interest to NBS programs are fire research, plumbing, and acoustics. Information on CSTB is contained in reference 2 (in French). Another description of CSTB (in English) is in Appendix B. An organization chart is included in reference 3.

A general description of French scientific and technical research is contained in reference 1 (in English).

2.2 Organization of Reports

The team itinerary was broken down into the eight topics listed below. Although more than one person frequently participated in each topic (see section 1.1 and 1.4 for complete itinerary), only one person as listed below was responsible for reporting particular topics.

1. Economic Appraisal in Buildings - Thompson
2. Assessing the Quality of Buildings - Ware
3. Agreement System and Full-Scale Testing - Gray
4. Advancement of Applied Building Science - Rubin
5. Industrialized Buildings - Leyendecker
6. Soils and Foundations - Leyendecker
7. Plumbing Systems and Research - Thompson
8. U. S./French Program Coordination - Thompson

Topics 2, 3, 4, and 5 were actually covered by several persons, hence there may be some overlap in the individual reports. The team members reports are presented by author as shown below:

- Section 2.3 V. E. Gray
 - Topic 3. Agreement System and Full-Scale Testing
- Section 2.4 E. V. Leyendecker
 - Topic 5. Industrialized Buildings
 - Topic 6. Soils and Foundations
 - Miscellaneous: Structural Model Laboratories
- Section 2.5 A. I. Rubin
 - Topic 4. Advancement of Applied Building Science
- Section 2.6 H. E. Thompson
 - Topic 1. Economic Appraisal in Buildings
 - Topic 7. Plumbing Systems and Research
 - Topic 8. U.S./French Program Coordination
- Section 2.7 T. E. Ware
 - Topic 2. Assessing the Quality of Buildings

2.3 V. E. Gray

Topic 3. Agrément System and Full-Scale Testing

REPORT ON
U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

by

V. E. Gray

Materials Durability and Analysis Section
Building Research Division

TOPIC NO. 3 AGREMENT SYSTEM AND FULL-SCALE TESTING

A. Agreement System of CSTB

The organizational structure, operational functions and technical manpower of the Agreement Service of the CSTB were analyzed and appraised as to the applicability of such a system to the building process in the United States.

The organizational chart of the Agreement Service is shown in figure 1 (a more complete organization chart is contained in reference 3). The chart shows the three main divisions and the three sub-divisions of Section III. Two are concerned with materials and one is concerned with methods of construction or overall structure. The Agreement Service is the group which has the official function of testing and evaluating materials, components and fabrication techniques used in social housing sponsored by the French government. This group is composed of engineers, technicians and other specialists who may use 10 to 80 percent of their time on Agreement testing and the remaining time on research or other test development. Most of the high-level personnel have research positions and are used in the Agreement testing only as needed. In 1967, approximately 40 percent of the support of this group was received from Agreement contracts and tests.

The Mineral Materials Division has four sections dealing with inorganic building materials. These sections are responsible for testing of plaster, clay products, gypsum, concrete beams and floor units, flue pipe and concrete building blocks. They have laboratory facilities for physical testing of these materials as well as environmental chambers in which are measured the effects caused by humidity and temperature changes.

The Organic Products Division has its program divided into six areas. They conduct research and tests on (1) plastic floor coverings, (2) carpets, (3) coatings (exterior and interior), (4) smooth coatings and adhesives for floors, (5) roofing and (6) joint sealants and gaskets.

F I G U R E I

AGREMENT SERVICE

Service Chief - M. Roger

I MINERAL MATERIALS DIVISION (MM)

Division Chief - M. Chabrel

II ORGANIC PRODUCTS DIVISION (PO)

Division Chief - M. Farhi

III METHODS OF CONSTRUCTION DIVISION (PC)

Chief Engineer - M. Mathez

A - Floors and Stairs (PC_o)

Division Chief - M. Mathez

B - Concrete Construction

Division Chief - M. Lugez

C - Light Weight Exterior and Partition Walls

Division Chief - M. Berthier

The Division on Construction Procedures is concerned with the testing of building components and assemblies. This involves mainly the testing of floor and wall components as well as the evaluating of various designs and techniques used to join these components. The sub-divisions IIIA and IIIB work with concrete construction, whereas IIIC evaluates the various composites of wood, metal and plastic used in wall units. These lightweight materials are gaining in usage but are still not as important as concrete materials in France.

The Agreement Service operates as an evaluation and acceptance agency for the social housing program in France. (This would be called "subsidized housing" in the United States). The ninety federal districts are able to use the facilities of CSTB, through the Agrément Service, to assess the value of proposed methods of construction.

Proposals submitted for approval or "Agrément testing" are usually materials or systems that have been found to be successful in the private building sector and are not usually new or untried materials or techniques. This explains the very low rejection rate. Only 5 percent of the proposals are refused approval by Agrément's Commissions. Some modifications are recommended for some of the proposals, but 95 percent are approved.

The proposals for Agrément approval are judged according to four general criteria of (1) safety (sécurité), (2) durability,

(3) habitability and construction feasibility.

The Agrément approval system is controlled by the French government through the CSTB. It is partially (40 percent) supported by fees charged to the manufacturer of contractor who requests an evaluation of his proposal. His proposal may be approved for use up to three years' duration. At the end of this approval period it may be assessed again with or without modifications as requested by the manufacturer. The second approval can be given for up to three years, also. After ten years of satisfactory performance the material or technique can be accepted as a standard or as a code of practice. Many times the manufacturer would rather maintain the Agrément status for his proprietary products.

There are presently three kinds of approvals: (1) Agrément Simple, (2) Agrément Suivi and Marque, and (3) Agrément-Type. The second type of approval is for products which have the quality control methods checked by CSTB and will therefore be entitled to mark their production with the CSTB stamp. The third type of Agrément seems to be relatively new and gives approval and describes a system (i.e., floor construction) and lists several of the approved manufacturers of this system.

Appendix F includes a "Schedule of Fees For Agrément Testing" - November 1969.

B. Applicability to U. S. Building Industry

The Agrément Approval system has served a useful function for the French social building program during the last 15 years. It has been able to do this because the French building industry appears to have changed slowly during this period with few innovations but many modifications of accepted systems.

Several areas of testing and research on materials and construction procedures appear to be adaptable to the U. S. Building Industry. For example, the Agrément Service has established performance criteria for floor coverings and wall panels, and has a system of tests with which to evaluate new materials.

For flooring materials a five parameter system called the UPEC classification is used. By various laboratory tests flooring materials are rated according to their relative resistance to (1) wear, (2) indentation, (3) water, (4) chemicals, and (5) sound transmission. These materials are then stamped with appropriate classifying numbers. Materials can be selected for specific applications by choice of the proper class under the five categories.

Another system has been developed for the classification of wall panels. Under this system tests are conducted and the panels are rated as to their (1) moisture resistance - E, (2) exterior durability - d, (3) strength and fire resistance - R, and (4) thermal transmission - K.

The Agrément system has provided a procedure whereby larger scale modifications could be tested and given official technical approval. This is similar to the "Phoenix Project" at NBS, but has been used with more benefit by the French.

2.4 E. V. Leyendecker

Topic 5. Industrialized Buildings

Topic 6. Soils and Foundations

Miscellaneous: Structural Model Laboratories

REPORT ON

U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

by

Dr. Edgar V. Leyendecker

Structures Section
Building Research Division

TOPIC NO. 5 INDUSTRIALIZED BUILDINGS

A. Background and Scope

Industrialized buildings (buildings factory-produced or on-site-produced using assembly line techniques) have been used in France for about fifteen years. These systems account for the production of more than 100,000 dwellings per year and a total of more than one million since their beginning. The market for industrialized buildings appeared in the years after World War II when there was an immediate need for new housing and very little skilled labor to build them. Impetus has been provided by a highly centralized government and a uniform performance type building code for the entire country. The establishment of the French Centre Scientifique et Technique du Batiment (CSTB) provided a government laboratory to evaluate different types of industrialized buildings. CSTB also provided a means to evaluate innovation in buildings.

Industrialized buildings are now becoming important in the U. S. market. "OPERATION BREAKTHROUGH," recently initiated by the Department of Housing and Urban Development (HUD), has helped to spur the formation of companies interested in manufacturing industrialized buildings. Since the use of industrialized buildings in the U. S. will surely expand, it is worthwhile to investigate the "state of the art" in France.

It is also useful to examine the test methods used to evaluate such buildings, both for strength and behavior. This was begun during this exchange program.

B. Program

During the course of the stay in France, several factories and building sites were visited by Thompson, Leyendecker, Ware, and Rubin. All team members did not visit the same places. Some time was also spent with CSTB personnel obtaining their opinions of various industrialized building systems and the techniques used to evaluate them. The value of this exchange with CSTB personnel was quite important since they have done research on almost all systems used in France. Some of the statements made in this report are based on the opinions of these researchers.

C. Types of Buildings

Many of the construction systems are adaptable for numerous purposes such as housing, schools, hospitals, and general purpose buildings. Most of the construction is done with concrete or concrete and brick combinations. The number of building systems in which steel is the primary fabrication material is limited.

Only one apartment complex visited was fabricated with steel (and aluminum). The structure consisted of a central

core fabricated from rolled steel shapes. Large steel floor space grids are cantilevered out from the center core, later, exposed columns are placed at the free end of the floor section. This system seems to be competitive with concrete systems, although final cost figures are incomplete. CSTB personnel are still conducting research on this building system.

There are numerous concrete systems, frequently only minor variations appear among them. Rather than identify each site and type of system visited by name, the types of buildings used will be placed in categories. The following types of systems are in use:

1. Precast boxes
2. Precast frames (beams and columns)
3. Precast panels
4. Combinations of 1, 2, and 3
5. Cast-in-place systems
6. Combinations of precast and cast-in-place elements.

Types 1, 2, and 4 are not widely used. Types 3, 5, and 6 seem to be in general acceptance, in particular there are many varieties of panels in use. The concrete used in almost all systems uses normal weight aggregate almost without exception.

Prefabricated panels or boxes may be built at the construction site or a factory some distance away. It appears that factory precasting predominates. Although prefabricated panels are popular there are difficulties in obtaining joints

with good thermal insulation and water tightness in some building systems.

The forms used in cast-in-place construction are as mechanized as is economical to keep the need for skilled labor to a minimum. Two types of forms are popular for casting "tunnels." One tunnel form consists of two vertical mold surfaces and a flat table top, all fixed to a supporting steel core. The three mold surfaces are arranged so they can be retracted for demolding. Another type of tunnel form uses two inverted "L" shaped forms to cast the tunnel. The combination of such cast-in-place floors and interior walls with prefabricated exterior walls is becoming very popular.

At one time, some of the tunnel molds were mechanized to the point of being self stripping and propelling. This was found to be uneconomical since it meant that workmen required for certain tasks would stand idle while the automation process was in progress.

It was also observed that in many cases there was no vertical or horizontal reinforcing steel in the cast in place load bearing walls except around openings. In the U. S. there is a minimum amount of reinforcing steel allowed in such walls even if calculations indicate it is not required; this is not the case in France.

D. Types of Plants

Two different principles of plant operation were observed. In the first of these, the component being fabricated remained at one location or station, with the various operations such as casting, finishing, etc, coming to the component. The second procedure has such operation at a fixed station with the component being moved by some means to the work station. Both types are in use. One owner stated that over-mechanization caused high costs due to idle labor.

E. Guest Worker and Information Exchange

It is not necessary to send a guest worker for an extended period of time. It could be profitable to send some HUD personnel to spend some time visiting factories and building sites. The information exchange with CSTB should be continued and expanded. Their experience in building evaluation should be profitable to NBS and HUD.

F. Further Information

Detailed information on numerous industrialized buildings in use in France is contained in reference 4. Although this reference is in French, there are numerous photographs which illustrate fabrication methods and completed housing.

TOPIC NO. 6 SOIL MECHANICS AND FOUNDATIONS

A. Background and Scope

Although foundations currently account for approximately 20 percent of the total structural cost of buildings, the Building Research Division does not have a program or facilities to do research in soil mechanics and foundations. The expansion of our population in urban areas causes an increased demand for building sites and an increasing scarcity of sites with favorable foundation conditions, thus further increasing the cost of foundations and increasing the chances of foundation induced problems. The science of soil mechanics and the art and science of foundation design have made great strides in the last decade, however, foundation design is still basically empirical. Any advance in the state of the art of soil mechanics and foundation design and any improvement in existing codes will not only decrease construction cost, it will also help prevent costly and dangerous structure failures. Because of this, a research program in soil mechanics and foundations is desirable in the Building Research Division. Due to the lack of facilities, such a research program can possibly be started and results realized most rapidly by using equipment at other laboratories through a guest worker system or by an exchange of technical information.

With the above in mind, an examination of French facilities was made in this first exchange in the U.S./French Cooperative Program on Building Technology.

B. Program

Two laboratories with a soil mechanics and foundations research program were visited. These were the Centre Experimental de Recherches et d'Etudes du Batiment et des Travaux Publics (CEBTP), which is a private laboratory supported by the construction industry, and the Laboratoire Central des Ponts et Chaussees (LCPC), which is a Federal laboratory of roads and bridges.

In addition, two construction sites were visited. Some time was also spent with Henri Vidal, the originator of the concept of reinforced earth.

C. Research Facilities

1. CEBTP

The CEBTP has a Paris laboratory and a Saint Remy les Chevreuse laboratory. Routine tests (such as triaxial compression tests, unconfined compression tests, and consolidation tests) are performed at the Paris laboratory which is well equipped for these tests. Research using small scale models and approximately half-scale models is done at the Paris office. Among the work being performed currently are small-scale model tests on bearing

capacity in cohesionless materials and on bearing capacity in the parois moulees construction procedure. The latter is a procedure whereby an area to be excavated (such as a building foundation, underground parking, subway, etc.) has an in situ wall cast around the site. The wall is cast by excavating a trench the width and depth of the wall, using a slurry to keep the walls from collapsing, and then using tremie concrete to cast the wall to the depth of the excavation. The research is on the load capacity of the earth near the slurry filled trench. Two construction sites, one an office building and the other an underground parking lot, where parois moulees were being used were visited.

Two reinforced concrete pits about three meters by three meters in plan by six meters in depth are available at the Paris laboratory for performing one-half scale tests. At this time, these pits are being used to check scale effects of the small-scale model tests carried out on bearing capacity of cohesionless soils and parois moulees.

The Saint Remy site has large scale pile and retaining wall testing facilities. The pit for testing piles is 6.4m in diameter by 10.4m in depth. Different types of piles cast or driven into various soils can be tested. Retaining walls subject to active and passive earth pressure can be tested in a pit with a retaining wall surface approximately eight by six meters. The wall may be inclined or vertical and loaded with

inclined or vertical loads. The type of soil and its configuration may be varied as desired.

All of these programs have practical use since they are aimed at studying the validity and range of use of existing theories.

Further descriptions of CEBTP facilities are contained in reference 5 (in French).

2. LCPC

The LCPC Paris laboratory was visited. The Department of Soils is divided into four sections.

- a. Geologie et Prospections
- b. Geotechnique Routiere
- c. Mechanique des Roches
- d. Mechanique des Sols

Only the latter section was visited. This laboratory has equipment to do routine type of tests similar to the CEBTP laboratory. In addition, there are nine field test sites where work is being done on pile capacity, bulkheads, embankments, and slope stability. The laboratory has also done research on a design procedure referred to as reinforced earth. The design concept of reinforced earth, developed by Henri Vidal, is a procedure for building vertical earth retaining walls by combining earth, horizontal layers of reinforcement, and a metal skin at the vertical boundary. One half day was spent with Mr. Vidal and Mr. Godet (employee of Mr. Vidal) discussing the principles and uses of reinforced earth.

D. Program Evaluation

The research facilities at CEBTP and LCPC are excellent, both in small and large scale work. The LCPC research is more limited in scope since it is a laboratory of roads and bridges. The research at both laboratories is useful for both the U. S. and France since they are concerned with the validity of existing theories in general use.

E. Guest Worker and Information Exchange

Cooperation with the U. S. and France through NBS in the area of soil mechanics and foundations at this time would be one sided due to the lack of NBS facilities. At the minimum it is felt that CEBTP (due to its more general nature than LCPC) can be very helpful in getting NBS started in research in this area. Their experiences in establishing a laboratory and obtaining dependable equipment would be quite helpful to an NBS program. Knowledge of the research performed and the test results will also prevent NBS from repeating research that has been done. The initial technical contact established during the first exchange should certainly be continued. Possibly, a guest worker from NBS could obtain much of this information first hand while performing research useful to both countries. Since the CEBTP appears to be well equipped for general research, this latter possibility should be explored.

MISCELLANEOUS: STRUCTURAL MODEL LABORATORIES

The CEBTP and LCPC structural laboratories were also briefly visited.

CEBTP

The CEBTP laboratory has an excellent facility. There is a large test floor with a general purpose storage space underneath. This is currently being used for conducting tests on creep specimens in a controlled environment and also conduct experiments on small scale models.

The structural models laboratory is doing research on various types of structures and measuring techniques. At this time, only linear elastic materials are used in the model fabrication. Experimentation has been started on using a holographic apparatus for measuring model deformation.

LCPC

The LCPC laboratory is equipped to test full-size members and small-scale members. Work has been done on models using the classical methods of photoelasticity, electric analogue, and linear elastic materials. Efforts are currently underway to do research using models fabricated from more realistic materials approximating prototype materials. Due to the nature of the laboratory, most of the research is on bridge related structures.

Comments

Although the structural laboratories were not a part of the official exchange, they were worthwhile to visit. The writer was not aware of the structural models work being done at CEBTP. This area of structural models is of particular interest to the writer since he is in the process of beginning models work at NBS. This is a field where an exchange of information should be started.

2.5 A. I. Rubin

Topic 4. Advancement of Applied Building Science

REPORT ON
U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

by

Dr. Arthur I. Rubin

Psychophysics Section
Building Research Division

REPORT ON U.S./FRENCH COOPERATIVE PROGRAM

by

Dr. Arthur I. Rubin

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I. PROGRAM AREAS

	<u>Personnel Visited</u>	<u>Organization</u>
A. General Background	Mr. Blachere	CSTB
B. Building Quality	Mr. Cami	CSTB
C. Acoustical	Mr. Josse	CSTB
	Mr. Dawamce	CEBTP
D. Thermal	Mr. Croiset	CSTB
	Mr. Clain	CEBTP
E. Lighting	Mr. Dourgmon	CSTB
F. Space Perception	Dr. Chabrier	CSTB
G. Industrialized Building	Mr. Hierholtz	CSTB

II. PROGRAM SUMMARIES

A. General Organization Backgrounds

Two organizations are concerned with research activities analogous to those performed at BRD/NBS, CEBTP and CSTB.

1. CEBTP is an organization of private building contractors concerned with materials, appliances, products, test methods, etc. which maintains laboratory facilities for testing and problem solving activities. Much of the work is performed for individual contractors with test results submitted in the form of confidential documents. Some of their work is subsidized by the Government and is designed to supplement the experimental capability of the Government laboratory, CSTB. The staff consists of approximately 250 people who have modern research facilities for work in areas such as acoustics, heating and ventilation, plumbing, etc. Staff personnel also conduct courses lasting one year in programs associated with their specialty. Students consist of recent graduates of technical schools who are sent by manufacturing organizations for training in these disciplines. Two week management courses are also taught at the school.

2. CSTB primarily functions as a governmental organization although its staff does not have "civil service" status and its research is partially funded from private sources. Its research interests are more broadly based than that of CEBTP and has several non-research responsibilities as well.

a. Mission

(1) Proposes Building Codes - On the basis of information gathered experimentally, analytically and in conjunction with other organizations, building codes are proposed. As part of this process, CSTB works with all interested groups for unanimous acceptance of the codes which are formulated.

(2) Provides Expert Advice - Consultation with governmental and private institutions on matters concerned with building is another major responsibility of CSTB.

(3) Performs Research for Standards and Product Testing - Together with CEBTP, a comprehensive test program associated with building construction is performed on materials, equipment, processes, etc. Test results, unlike those of CEBTP, are published in the open literature and/or by the organization.

(4) Devises New Systems of Construction - Is responsible for developing innovations in the building process designed to advance the state-of-the-art in building construction.

b. Research Approach

The organization of the activities of CSTB is seen to consist of four major areas which are constantly interacting with one another to accomplish one overall purpose, i.e., advances in building technology.

(1) Full-Scale Natural Applications - The translation of research and other activities in new methods of building.

(2) Technological Testing - Determining adequacy of building "subsystems", equipment, appliances, etc.

(3) Application of Human Sciences - Determination of the affect of the environment on behavior, e.g., thermal comfort, appraisal of interior space, noise, natural and artificial illumination.

(4) Application of Results - Updating the Agreement system and methods of standardization.

c. Staff and Facilities

The staff consists of approximately 400 (?) people, 100 professionals and the remainder technical and administrative support. The laboratory has modern research facilities for work in acoustics, thermics, plumbing, fire research, etc., at Champs. A number of activities have been moved (or will move) to the provinces in accordance with plans for decentralization. At Nantes, work will be performed in lighting, wind, social science and humidity transfer. At Grenoble, the CSTB laboratories will share facilities with a university as well as the Center for Nuclear Studies. Investigations will be performed in Solid State Physics, aging materials and acoustics.

Half of the staff is located in Paris at the Headquarters of the Organization, which serves as a point of contact with other groups concerned with buildings.

B. Building Quality and Systems

1. "Evolution of Doctrine"

The two world wars led to a rethinking of the building process. Prior to the first war, the building procedure employed consisted of a very slow and careful approach. It entailed the thorough testing of each new technique demonstrating performance reliability before any application. A high demand for new construction, coupled with a shortage in some traditionally used material led to the use of new materials. The quality of these new materials had to be evaluated and compared with those used in the past and time constraint didn't permit the "old" methodological methods of testing used formerly. A rethinking of the building process was thought to be in order.

a. Approaches Attempted

(1) Define Elements and Qualities Demanded - This

(1) Auditory - Noise levels known to result in physiological damage are known and therefore upper noise limits can be specified if ear damage is a criterion. (Levels which are acceptable for equipment, aircraft, autos, etc., are also specified but are not as well known. However, there is an ongoing research program to provide more adequate data).

(2) Thermal - Specifications are made with respect to wall dryness, air movement and temperature. (Research defining thermal comfort is being pursued.)

(3) Visual - Requirements as to lighting needs are noted. (Some research defining natural and artificial lighting parameters has been performed.)

(4) Safety Factors - Protection against burglary, animal intrusion, fire and household accidents are included in this category.

(5) Sociological Factors - Individual living requirements in a social setting are noted. Among the considerations is the need for isolation of each person from other family members as well as between families. There is an emphasis on the need for private spaces for each person. Requirements for suburban and urban living are each taken into account. (Research program being planned.)

(6) Adaptability of People to Living Quarters - Determination of methods of allocating spaces to activities within a building. (A study is presently under way using two possible approaches: 1. The architect attributes functions to spaces. 2. People are permitted to use spaces for any activities that they consider appropriate.)

(7) Resource Use - Determination of the use of water, gas, electricity.

(8) Economic Factors - Specification of the durability of materials, appliances.

(9) Environmental Factors

(a) Natural - Information concerning climatic conditions, wind streams, snow loads, humidity, hailstones, sun radiation, etc. (Data collection and organization is under way because of the inadequacy of the data base. Meteorological data from national sources are not considered adequate because the stations are far apart, data are in the form of extremes and averages but sequences of weather and durations of each cycle are very important. Micro-climate conditions are not

well understood, i.e., general ground conditions, effects of lightning, pollen, high ionization, radiation of heat from sky to earth and heat reflections from the ground, etc.)

(b) Artificial -- Determination of the effect of noise, lighting, heating, air purity, etc., on the habitability of a home.

2. Research Areas - Information is organized by categories, as follows:

- a. Framework
- b. Heating, ventilating
- c. Lighting
- d. Water distribution
- e. Power supply
- f. Gas
- g. Garbage disposal
- h. Telephone
- i. Radio and television (antennas)
- j. Lighting conduction
- k. Interior devices for moving

3. Research Approach - Problems are most often approached, starting with the human requirements, termed synopsis. In some instances, however, the starting point is the material and its characteristics which is then translated into a design solution. This latter approach is called an inverse synopsis.

a. Sample Problem (synopsis)

There is a need for acoustical privacy to perform many activities in the home. For example, noise measurements for a sleeping area shouldn't exceed 25-30 dBA, while for a dining area, the levels suggested are 30-35 dBA. In the example given (Table I), traffic noise has been measured at 70 dBA. In order to meet the requirements for acoustic privacy the "options" include wall transmission losses of 40 dBA (for sleep) and 30 dBA (for dining). These figures are obtained from reference works (codes) indicated in column (d) and are based on experimental data. An additional requirement established to meet the acoustic criteria is that there be no exterior intake. This latter restriction will be cross referenced under "Heating Requirements". In a similar manner problems (2) and (3) in Table I are treated by moving across the body of the table from left to right.

b. Sample Problem (inverse synopsis)

This approach consists of a highly detailed description

TABLE I

Requirement - Need for Acoustical Privacy

a Exterior Data (Problem)	b Requirements	c Options (Material)	d References (Codes)	e Justification
70 dBA (car noise)	Acoustic 25-30 dBA (sleep)	40 dBA Wall Transmission Loss	B	Experimental data
	30-35 dBA (eating)	30 dBA (No exterior air intake)	B ₂	
Apartments are noisy	48 dBA	300 KG/M ²		Scientific-Mass Vibration Data
Air conditioning is noisy	Air conditioning conduits - noise treated			Past experience

of the physical properties of a house.

Description of House (general)

- (1) Exterior Walls
- (2) Roof
- (3) External Openings

(1) Exterior Walls (Further Breakout)

- (a) Low Part (foundations)
- (b) Window Sills
- (c) Mullions

(b) Window Sills (Detailed Breakout)

- 1. frames, metal
 - a. drawing of frame
 - b. drawing of type of glass placement

(1) Exterior Wall Requirements

(a) vertical - non load bearing

- 1. fixed windows (1.5)
- 2. thermal load ($K = 1.8$)
- 3. sun protection factor (0.15)
- 4. acoustical absorption (40 dB)
- 5. no vents
- 6. ground window sill depth ($K = 0.8$)
- 7. sill edge - metallic (varnished)
- 8. fire proof - 1 hour (CSTB exp. #)
- 9. wind resistance
- 10. rain/snow - (water resistant under specified conditions)
- 11. outside wall - fireproof under conditions of _____

3. Critique - Comments limited to concept and approach of habitability as a design criterion.

After attempting several research approaches, CSTB determined that "habitability" was the key criterion in assessing the adequacy of proposed designs. Unfortunately, however, there is almost no evidence that sufficient resources are being expended in defining the human needs which constitute "habitability". The human science group at CSTB is admittedly

very weak with respect to both staff and facilities and worst of all in the level of support they receive from management with respect to priorities. The social and psychological measures always follow the lead of the physical measurements in interdisciplinary programs. It should be noted that historically, the French have been quite weak in experimental design in the social and psychological sciences, and the staff of CSTB reflects this weakness. The absence of a meaningful research program in the human sciences which is necessary to define "habitability" casts a great deal of doubt on the adequacy of their criterion measure which is the basis of their entire research effort.

C. Acoustical

1. CSTB - A broad range of activities are covered by the research performed by the acoustics section. Among them are the following:

a. Noise Measurements

- (1) aircraft noise - near airports, in urban areas, sonic booms
- (2) automobile noise - near highways, within Paris
- (3) equipment noise - plumbing fixtures

b. Advancing Methodology in Measurement

- (1) comparing laboratory and field measures
- (2) developing simulation

c. Developing Noise Reduction Techniques

d. Determining Human Response to Noise

Research programs in most of these areas are currently under way. In one ongoing study, measurements of street noise are being made in several sections of Paris. Data concerning the

physical characteristics of sounds are being recorded and analyzed (to some extent) by placing equipment modules in apartments. Measurements are taken inside and outside of preselected window locations at a variety of levels and distances from the street. Concurrent with data collection on the physical characteristics of sound, a survey is being planned to determine the subjective response of people to street noise.

Another study of interest concerns the attempt to simulate traffic noise and to determine the effect of barriers on reducing noise levels. The simulation of traffic noise is accomplished by activating a series of bells, with fundamental frequencies of 500 and 100 Hz. Each bell is positioned so as to produce sounds which are uncorrelated with those of all other bells. A spectral analysis of automobile noise led to the conclusion that the high frequencies cause most of the noise problems and therefore ought to be examined in detail. In conjunction with the "traffic noise" source, screens (barriers of any kind which prevents a direct line of sound transmission) are placed at a variety of heights, characteristics, distances from the noise source, etc., to determine methods of noise attenuation which might be feasible.

A machine has been developed for use in impact measurements. The sound source consists of either men's or women's shoes with a variety of configurations. The force levels used are based on empirical data obtained by averaging many individual observations. The instrument is only a laboratory device at present and systematic data collection on relevant parameters had just begun.

2. CEBTP - There is quite a bit of overlap regarding the research of CSTB and CEBTP in the acoustic area with both organizations concerned with equipment noise, noise control techniques and subjective response to noise. However, CEBTP functions largely as a testing organization responsible for providing information (in a confidential form) to product manufacturers concerning equipment noise and the noise transmission characteristics of materials.

3. Critique - Both CESTP and CSTB have extensive laboratory facilities and staff to perform comprehensive research

programs in acoustics. The problems addressed by the organizations are in many instances the same as those of concern in this country. The major difference is that they are engaged in research which has a good deal of support with respect to financing programs whereas the U. S. programs had to be discontinued after NBS moved to the Gaithersburg site. CSTB has been concerned with environmental noise for a long time and undoubtedly they have made many advances in developing an appropriate methodology that could be utilized in this country. There is also a history of concern with subjective responses but little demonstrated capability in this area. Unfortunately, there is an absence of scientifically trained researchers in the social sciences and this shortcoming is well known to the acoustical researchers as well as management. The result is that physical data collection takes precedence and subjective responses are tagged on almost as an afterthought in the design of experiments. Extensive surveys (of very questionable validity) are often conducted but there is almost no true interdisciplinary activity.

D. Thermal

1. CSTB - The current research program consists of the following major studies:

- a. Specification of power requirements for heating and cooling.

- b. Summer comfort in light structured schools. Many schools in southern France have extremely high temperatures during the summer. To overcome this problem, a school made of light-weight material was designed with large ducts, low ceilings and a concrete floor. This design was formulated to permit a forced

air exchange system, up to 20 times per hour while minimizing expenses. Subjective reactions are being obtained by teachers and students as to the effect of the lower ceilings (permitting placement of ducts).

c. Summer comfort in natural climatization. Research in desert areas to determine how best to cool homes without air conditioning. Designed to meet "social housing" needs.

d. Design of all-electric apartment houses. The goal is to determine feasibility of all electric heating with costs not to exceed 20 percent of conventional heating costs. The houses are for middle income families. Subjective data is also being collected concerning "comfort" of homes.

e. Use of hot air vents to supplement hot water floor heating in apartments. The program is designed to find efficient means of designing and placing vents to the outside in order to permit apartment occupants some control of their thermal environment. The centrally located hot water systems now in use permit almost no such control. Subjective measures of "comfort" are collected also.

f. Computerized operations In their computer facility it is possible to simulate the thermal environments of 3 rooms interacting with one another. The (analog) computer can handle 14 variables at a time. It is designed in a manner that resistance and capacitance are used to represent the characteristics of a wall. The time period sampled depends on the degree of steady-state conditions.

1. Computer uses

- a. General - Determine independence of parameters, how and under what circumstances they interact with one another in thermal problems. - Model building.
- b. Thermal exchange - heat capacity, conductivity.
- c. Conductive and radiant heating requirements.

2. Computer output

- a. Heat and air conditioning consumption.
- b. Power
- c. Inside temperature

3. Computer modeling

- a. Known material characteristics
- b. Unknown characteristics (parameters specified empirically)

- c. Interactions of known parameters - rooms and thermal exchanges.
- d. Data samples
 - 1) outside and inside temperature
 - 2) solar radiation
 - 3) long wave radiation (mountain areas)
 - 4) wind velocity
 - 5) relative humidity
 - 6) lighting
 - 7) occupation of room
 - 8) heat flow

2. CEBTP - A variety of programs are under way at present, some devoted to problem solving and others of more general interest:

a. Testing

- 1. Air conditioners and radiators
- 2. Fresh air heating systems
- 3. Chimneys designed to minimize air pollution
- 4. New instrumentation
- 5. Evaluation of standard test procedure (with one open wall) receiving and returning convectors being examined as well as radiators

b. Problem solving

- 1. Determining methods of overcoming loss of pressure in elbows of heating systems
- 2. Determining methods of overcoming corrosion in hot water heating systems
- 3. Performing experiments proposed by product manufacturers
- 4. Specifying heating and air conditioning requirements for buildings based on data sent by contractors. A computer is available to assist in the operation.

c. Research

- 1. Develop new measurements instruments and techniques
- 2. Computer modeling of newly proposed products
- 3. Simulation of effect of wind on a city
- 4. Thermal comfort - subjective responses to changes in a thermal environment

3. Critique - Both organizations have large and modern facilities to perform their research. CSTB in particular is using its computer in a number of innovative ways and is anxious to increase its capability in modeling and problem solving. With respect to thermal comfort, both organizations are concerned with the problem and are collecting data (of very questionable validity, unfortunately for the same reasons noted earlier).

E. Lighting

CSTB has an ongoing research program in lighting, which supports one full time professional. There had also been some activity in colorimetry but no work is currently being done in this area.

The experimental work is designed with the goal of "enriching: the visual environment. The research has taken several forms. In one study, subjects were permitted to vary the illumination in a room by selecting which of a variety of lighting arrangements were preferred. In another experiment, artificial and natural lighting sources were combined in order to give the impression that daylight was streaming into a room which had no window exposure for the most part. Plastics are being used to alter the visual environment by using opaque shapes to vary the viewpoint of the observer and translucent material to provide a transition zone between adjacent high contrast areas.

Another research interest has been to predict the effect

of shadows in order to appropriately plan building lighting. Models have been constructed which predict shadow patterns on windows, buildings, communities, etc., depending on parameters such as time of the year, time of day, latitude, building height and characteristics of surrounding area.

F. Space Perception

Just as the lighting research program is barely a viable one at present, the work in SPACE PERCEPTION is also limping along. There doesn't appear to be any active experimentation at present with the main emphasis being on the facility. They are equipped with an experimental room with movable walls and ceiling that can be manipulated by a researcher. Work in the past has been concerned with determining acceptable room dimensions for specific activities. Subjects were asked to indicate which room sizes they prefer while the room dimensions were being changed. Other research activities have dealt with the ability of subjects to correctly estimate distances monocularly and binocularly on the surfaces of the wall in the experimental room.

Critique - Lighting and Space Perception

Both research programs are to be moved to NANTES and this is one reason for the lack of ongoing research at present. However, the principal investigators in both areas noted that they would not move to the new location. Since there was no indication of any other staff concerned with the human sciences, there is considerable doubt as to the establishment of a worthwhile program of study in these areas.

The most interesting features about the research concerns the availability of experimental facilities to do investigations on space perception and room lighting. Rooms of this type would be very valuable for performing psychophysical research at BRD. They can be employed to vary dimensions and characteristics of a room in a realistic manner in order to obtain realistic and therefore meaningful subjective data.

G. Industrialized Building

A number of new communities in the vicinity of Paris were visited. They were selected as being typical of the construction technology developed in France in the past 15 years. Both middle income and "social" housing units were seen and in most instances were very impressive with respect to style and the quality of construction. Several places displayed common features, a centralized heating and air conditioning plant, a shopping plaza and a variety of houses, some of 4 stories (not requiring elevators) and other high rise buildings 15 and more stories in height. Precast concrete construction was used in all instances with the prefabrication plant on the pits in some instances and at a distant location, in others. In the latter instance, there was accessibility to railroad and other means of transportation readily available.

A number of apartments were visited, which appeared quite pleasant. The forced air and hot water heating facilities were pointed out as were other features of the houses. One feature noticeable in the low cost housing was the noise in the

corridors and hallways attributed largely to the hard surfaces everywhere.

An experimental village of single family dwellings was a highpoint of the tour. The houses were built, using experimental techniques, by a number of contractors. The builders were encouraged to innovate but to keep costs competitive with those in high-rise construction. The lots were extremely small but the builders made very imaginative use of all of the land. By providing "common" areas to several homes there was a good deal of open space with grass and trees. The acceptance of the houses was very high among residents of the community.

A middle class housing community 10 miles outside of Paris was visited also. The style was contemporary and athletic facilities and a swimming pool were among the attractions. The apartments were quite nice but the price for a dwelling unit was approximately \$45,000 with 20 years to pay. The loan was for 12% interest. (It is the custom to purchase apartments rather than rent them.)

II. EVALUATION OF BUILDING SCIENCE

A. Scope of Research

BUILDING SCIENCE research is theoretically closely associated with the work of the systems analysis group which is concerned with the building process. The concept of HABITABILITY provides the link between the mutual interests of the two disciplines. In both cases, the starting point of their

activities is the identification of a human need or requirement. (Need is defined as having a physiological basis while requirement is primarily psychological.) The HUMAN SCIENCES group is supposed to provide the relevant parametric data associated with an identified need. The data are gathered in one of two ways. When there is a rich data base, a review of the literature is sufficient to provide the required information. However, when the solution is not readily apparent, a research program is formulated, which is designed to produce the necessary data.

Conceptually, the research approach appears to be quite sensible but in practice it doesn't really work. The primary fallacy in the methodology employed (using HABITABILITY as a criterion) is that it assumes a well organized and detailed body of data in the human science area that simply does not exist in a usable format. The difficulty is that instead of providing most of the answers by means of a literature search or by the application of relevant experience, many needs which are identified, point to research programs designed to supply the missing data. However, since most design solutions depend on HABITABILITY information as a starting point, the absence of these data would stymie all progress. A "best guess" solution is therefore applied "temporarily" until definitive answers are obtained by means of in-house research. It can be seen that in all instances, the effectiveness of the problem

solutions based on HABITABILITY rest on a viable research program and a high degree of expertise in the HUMAN SCIENCES. Unfortunately, this is an extremely weak "link" in the research capability of CSTB. The HUMAN SCIENCES really do not exist as a research unit with defined responsibilities, working together with the systems group formulating programs designed to provide data on HABITABILITY. The fact of the matter is that there are several individual researchers pursuing specific experimental problems (with very small staff). A good deal of the work is only tangentially, if at all, related to the type of problems identified by the Systems Group. The worst handicap that they work under though is their status within CSTB. When work is performed within the HABITABILITY framework the collection of subjective data serves as an appendage to data collection in the physical sciences. For example, a survey of street noise in Paris is currently underway. The experimental plan was formulated by the Acoustics Section which detailed specific locations, sample size, times of day for data collection, etc. The Human Science activities of surveying attitudes toward noise problems were added on to the existing plan with very little or no say regarding the appropriateness of the methodology for subjective responses. This priority given to the physical sciences was also apparent when discussing visual, perceptual and thermal comfort research.

It should be noted, however, that the HUMAN SCIENCE

GROUP were very weak with respect to training and experience in experimental research. Historically, psychology in France evolved from philosophy and the tradition persists in the Universities that solutions to problems in the Social Sciences can be "armchaired". There is no strong tradition of an experimental and human factors approach to the solution of psychological and sociological problems. It is for these reasons that there appears to be a basic discrepancy between basing a systems concept on HABITABILITY which is defined by a solid base of data in the Social Sciences, and giving no support to building up any real experimental capability in that area, and even worse, not demonstrating an awareness that a problem exists.

B. Impact on Community

There is little evidence that the research performed in the HUMAN SCIENCES has had any significant or lasting effect on the scientific or building community. A number of innovative ideas have been proposed (in lighting for example) but have not been applied. The SYSTEMS group indicated that plans are being made to construct experimental dwelling units that are to be occupied for periods up to 10 years. Innovations are to be introduced in lighting, the employment of partitions, heights of ceilings and other design features. The residents are to be questioned as to preferences and subjective data compiled during the entire duration of the study. This is a description of an exciting research program which would provide long term

data in a situation where actual living conditions are sampled as opposed to data collection in the sterile environment of a laboratory. The program which provides an ideal framework for HUMAN SCIENCE study, was not even mentioned by any of the HUMAN SCIENCE researchers which poses the question of who (if anyone) is to conduct this research.

C. Relevance of Research to U.S. Problems

The research interests of the U.S. and France in the HUMAN SCIENCES are quite compatible. In both countries, the focus of attention is on the individual and the family unit at the present time. The problem approach in each instance is to identify individual needs in some manner that permits translation into a design solution.

Unfortunately, there is little compatibility between the stated objectives of CSTB and the ongoing programs of research. The investigations completed and those underway are very limited in scope for the most part although they are often basic in nature. They appear to be directed toward formulating tenable hypotheses rather than offering solutions to problems. As noted previously, however, their "mission" has been administratively defined in this way because of the pre-eminence of the physical sciences.

As noted previously, there is a major research effort underway at CSTB to determine the dimensions of the street noise problem in Paris. This investigation, which is the

prototype of several other planned studies, offers an opportunity to collect meaningful subjective information on a large scale. The primary difficulty is that because of the lack of know-how and the limited experimental control exercised by the HUMAN SCIENTISTS that there is little expectation (on the author's part) that valid data will result from these investigations. The scope of the FRENCH government's involvement in SOCIAL HOUSING (100,000 dwelling units per year at present) presents a unique opportunity to develop a worthwhile methodology by means of large scale data collection of subjective responses. With high level cooperation and the centralization of the French economy, it would be possible to make substantial progress toward developing a standardized questionnaire which can be used to provide information as to consumer's needs, defined by the consumer. This seems to be a reasonable and important early step toward defining HABITABILITY and NEED.

IV. FOLLOWUP TO VISIT

A. Future Visits to France

Researchers in the U.S. in the thermal and acoustical areas might profit from a visit to the CSTB and CEBTP facilities and an explanation of the ongoing experimental programs by the investigators performing the work. In the thermal area particularly a background in computer simulation would be valuable for the visitor.

B. Cooperative Research Program

It might be feasible to conduct a joint research program in the HUMAN SCIENCE designed to standardize data collection procedures associated with subjective responses concerning occupant's "needs" and requirements. The extensive data collection effort being undertaken in France concerning street noise is consistent with the interest of improving the quality of the environment in this country. The massive building program underway in France and now being planned in the U.S., provides another important overlap in concerns between the two countries.

The development of a methodology designed to provide information as to "consumer" preferences is a necessary step in building a data base that can be used by architects and builders. After the "needs" are initially defined, controlled laboratory studies can be conducted to better understand them. The next step in the research program would be to validate the needs by formulating design solutions and finally collecting subjective responses again to determine the degree of "consumer" acceptance.

2.6 H. E. Thompson

Topic 1. Economic Appraisal in Buildings
Topic 7. Plumbing Systems and Research
Topic 8. U.S./French Program Coordination

CSTB
CEBTP

REPORT ON
U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

by

Harry E. Thompson

Deputy Division Chief
Building Research Division

TOPIC NO. 1 ECONOMIC APPRAISAL IN BUILDINGS

Three days were spent discussing the economic appraisal of buildings with Mr. Charles Noel. Mr. Noel heads the Economics Department at CSTB. There are ten construction engineers or technicians in his department. He has no economist on his staff. Most of their time is spent on the social housing projects or public housing as it would be called in the U.S. The morning session on Tuesday, November 18, was spent on discussion of the French conventional methods describing building evaluation, quantities, and setting up prices. Then the quality and price combination (which is a procedure they have been working on for some ten years that was developed in their section) was discussed. According to Mr. Noel they work on anything to cut costs. They are looking at regulations, costs during the design process, costs related to standards or documents, standards costs that may be reduced regarding specifications, and costs related to contracts, and financing. They also work on contractual documents regarding costs in the execution of construction jobs.

The Housing Ministry in the social housing program has set up what they call ceiling prices and their subsidy is held to these prices. The ceilings were set up on March 21, 1966

and again in 1968. In 1968 there was a five percent reduction in these ceiling prices. The CSTB staff is not pleased with the ceiling figure which is based on a square meter cost. They think it should be developed on the type of unit, in other words three bedroom, two bedroom, etc. This ceiling is broken down into two areas: the building complex and the non-building items. The non-building includes fees, roads, services, lifts, and central heating equipment.

These ceiling prices are broken down into three zones: one is Paris and the other is zone A and zone B which are different geographical areas. The square meter ceiling in Paris is 900 francs; zone A is 700 francs; zone B is 800 francs. But of this total zone ceiling price in Paris the construction is only 55 percent of the 900 francs, so this leaves about 675 francs for just construction cost. The construction cost is 60 percent in zone A and 55 percent in zone B. These are generally ceilings associated with large building housing projects. The client can vary the room sizes with the quality if he can stay within these ceiling limitations. Therefore, there is a need in the CSTB fields to compare the size and quality and they have been working with the Ministry in developing a method which appears to be fairly comprehensive.

They have done other things through the years regarding these large housing projects to cut down costs. In 1952 through 1957 they had various types of contracts to suppliers for building items such as doors. They would get a price for doors based

on quite a large number of housing units. Then a general contractor would use these door prices and types in his housing projects.

In France there is an unusual situation, in that the construction contractors have escalation authority for materials and labor in their contract cost. They are permitted to receive more payment after the contract has been awarded if prices reported in the state indicate an increase in labor and material cost. The 20,000 indexes and changes in the index comes out every three months in magazine form. A copy of this file is available in BRD file.

A copy of the "Minimum of Specifications for Social Housing" that CSTB developed for the Housing Ministry is available in the BRD file as "Document No. 55-1394 DU 22 Oct. 1955." This document indicates what the national housing code is and gives the variations that can be made in the social housing project. This is a very handy document and as can be seen by reading it, it is mostly in the performance type language and fairly short.

A document entitled "Examination of the Quality of Construction Projects for Dwellings in Collective Buildings" or social housing projects is in appendix C. This gives, in some detail, the concept where they are able to compare price quotation of an enterprise or a price estimate for a project with the current prices on the market at a given time. They can compare them for quality of construction offered for this

price. This quality is broken down into a material content with a degree of satisfaction of different human requirements, usually these are sound and thermal. This document was made public in 1961 and is issue no. 38 with part 48 of what is called cahier's type publication made available to the construction industry. A number of these type publications on construction cost evaluation are in the BRD file. They have developed some fairly complex yet relatively easy to follow documents which compare the construction items that reference dwelling units with the items of an actual dwelling which contribute to its finished outfitting. Example, the finishings, everything which is apparent, the appliances; everything which was touched or manipulated; the habitable and the non-habitable areas, such as balconies, closures etc. The price that is used in this comparison has been taken from the table established for this purpose. The present table, that of 1967, was drawn up by a committee which included along with the members of the CSTB, the Ministry of Equipment, representatives of the building owners, quantity surveyors, architects, engineers and contractors. The format is fairly complicated and I have copies available for the BRD file. They have some plus and minus evaluations associated with the project which indicates that the project was better than the minimum ceilings, qualities, and also is very helpful to an architect or to the Ministry in evaluating the proposals that are submitted. These proposals or

evaluations are developed by the architect and contractor and submitted for approval. CSTB gets a copy, they then evaluate the proposals using this format. Then they meet with the Ministry of Housing (once a week) and give the evaluation or technical evaluation of the proposal. If CSTB finds something peculiar they are permitted to go directly to the contractor or to the local state authority to get clarifications on some of the inconsistencies or bad evaluation that they develop in reviewing the project.

There is a procedure that is followed in social housing. First, the central ministry gives the authorization to negotiate a contract which is good for three years for so many dwellings, at a certain price ceiling. This is given to the state housing people. The state housing people then work directly with the local director of social housing or client who is selected by the government and who selects a site. The local director purchases this site and then goes out to an architect or to a combination architect and contractor to develop the design. The architect or combine develops the minimum requirements format sheet that has been prepared by CSTB. They submit these to the Central Ministry. The Central Ministry then sends it to the Commission for Negotiating Contracts (CSTB is the technical representative). CSTB advises on the evaluation format that has been submitted. If the submission is satisfactory and CSTB recommends approval, it then goes back from the Central

Ministry to the State to the local director of social housing who awards the contract and gives the authority to go ahead with the construction. I asked CSTB if they had much time to evaluate after completion of construction (feed-back). They have had little experience on this because of their limited staff. However, in the last 10 years, there has been considerable surveying of completed structures that are used extensively for their computations and evaluation formats. Also with this information CSTB does develop statistical information for the Ministry of Housing. These are cost information. They generally submit this every 6 months. A copy of their latest report is in the BRD file. One of the items of interest in the latest report is the indication that the quality of housing is going down, which is of considerable concern to CSTB.

In the afternoon of Tuesday, November 18, I met again with Mr. Noel and Mr. Hunt and reviewed what they call a Rational Cost Analysis. This has the initials ARC method and it is the method for rational cost analysis. See appendix D for an English translation. This is a tool developed at CSTB for the rapid appraisal of projects for the analysis comparison of costs. Its starting point is different from that of conventional quality measuring methods which involve merely the calculation of expenses without attempting to classify them other than by groups of elements and by trade. In opposition the ARC method is designed primarily to classify expenses according

to rooms or groups of rooms in accordance with the dimension and shapes of the volumes and the kind of materials and equipment used. Each room constitutes a box with its own element and its own specific equipment. The ARC method is apparently, a good method to calculate in the quantities of each element according to design and specification of elements. Its use of cost evaluation or cost comparison requires knowing the unit prices of different items. These prices are not different from those used in conventional estimating methods. They claim that instead of multiplying the prices by quantities it is just as easy to apply quantity to materials or labor thereby committing all outlay estimation often used by contractors in establishing their prices rather than using the unit prices of the element. The analysis then offers by the method, results from the grouping of prices by type of room and type of element. The rapidness of the method depends on the desired accuracy apparently and on the quantity of the data. CSTB claims that the risk of error is very small in comparison with the conventional methods estimated which appears reasonable. CSTB has also developed extensive use of tables and charts relating to this and this does reduce the possibility of calculation errors. Also the repeated use of these methods makes it possible to correct statistical ratios which constitute warnings if the figures look unusual.

The program has already been established in CSTB with the use of an IBM computer. Making this program available to the public is being considered at this time and it appears that it will be available very shortly. The BRD file has a number of French publications on cost analysis.

In the afternoon session I was able to review the program and the use of the computer. It looks very good. The following day (November 19) I was able to meet with a large architectural-engineering firm which will use this CSTB document as a tool for as an example to their own organization. There also appears that this is a type of a document that could be developed for buildings other than housing.

The ARC method offers three possibilities of estimation; one is by the element or by room, second is by square meter or room or groups of rooms and third outlays of materials, labor, etc. The analysis applied to a given project makes it possible to reveal what normalities in the expenses attributable to these different methods. If this analysis is carried out early enough it is possible to modify the project. The program has been reviewed by many other countries who have visited the area. CSTB has made translations of the documents and have written international publications. They had a Swiss guest worker for a year who took this back to Switzerland and has done some work in this method in his own country. The construction industry is very interested in this document.

They feel it would be a very good rapid tool for them to use for the construction industry in France.

On Wednesday, November 19, I spent more time with CSTB on the ARC method going into more detail on how they arrived at some of their information taken from example projects. In the afternoon I had a very interesting discussion with an organization called Omnium Technique de l'Habitation (OTH) which is located in Paris. OTH is a very large design and construction consulting firm doing work all over France for architects and engineers. Considerable time was spent with their estimating section talking over their procedures and their evaluation of some of the things that CSTB is doing.

In discussing the estimating procedures with OTH they indicated three phases of estimating and survey work that they do. The procedure is fairly similar to the U. S. procedure. However, with the bill of quantity with their final estimate, they do obtain then from the contract the unit price of all of these different quantities that is included in the project. The architect includes the quantities and the contractor provides the unit price. In the unit price, the contractor does not break down the material and labor. This is a lump sum price for the unit with the labor and materials. They feel that the general contractor would never provide labor costs.

The three phases of estimates include: first phase which is a very rough estimate based on sketches; the second

phase which is based on preliminary drawings including floor plans and elevation (they are more precise estimates) and the third, which is with final working drawings. The third phase is fairly time-consuming by the surveyor taking all of the bill of quantity off the drawings. I met with the project manager for development whose name is Marc Gamboulide. He had visited NBS last September attending our Pre-Coordination Conference. He is very interested in having his New York representative visit NBS.

On Thursday, November 20 I spent an evening at CSTB with Mr. Noel and Mr. Duc. We discussed the document that they prepared last December, "The Systematic Method to Describe Buildings". A copy is available in BRD file. The first part of the document that had been discussed with Mr. Tom Ware. The part that I picked up started on section 5, page 62. This is the descriptive part. The document was developed by a committee or group which included two architectural firms, one in Mantise and one in Marsay, and other groups in the building industry in France. The purpose of this document was to develop some type of method to describe buildings rather than use the extensive contract specifications that have been used similar to that of what we have in the United States. Of concern in the French building industry and the architectural profession was the voluminous specifications that were used on contracts and the problem of coordinating between the various parameters of the

work. Apparently, there is some disagreement between the CSTB staff and the architects who worked on the document but it appears to be one approach that may bear some looking into by the United States. It may be well to get some parts of the document written into English.

The descriptive part, is broken into what to do, what and how it should be done, who should do it and when is it installed. The tables have the items broken down into items built on and off the site. There are some 120 items. There is another document that we discussed (a checklist type of document) that they are presently discussing with the construction people. They indicated it would be complete in a few months and that they would send us a copy.

TOPIC NO. 7 PLUMBING

On Thursday, November 27, I spent the whole day looking at the plumbing facilities, at CSTB laboratory at Champs sur Marne. The head of the plumbing operations is Mr. Chargrasse. I met with him and his staff. Appendix E includes the agenda of the topics discussed.

This group had only two people in 1960. Now they have 45 people which includes 25 engineers, 15 technicians, 3 operating personnel and 2 clerical. This staffing though includes functions that would not normally be found in a plumbing program, including paints and enamel finishes. These are finishes not only associated with the bathroom areas and fixtures but wall finishes in other parts of a building.

As regarding, agrément the only thing involved here is primarily some agrément they have developed on plastic piping.

Approximately 80 percent of the work in plumbing is strictly associated with development of standards and for a large testing program where they provide the certification of fixtures, fittings and piping (mostly plastic piping). That leaves only about 10 percent of their work then associated with research. Last year this percentage on research was down to 2 percent. They are interested in a U. S. guest worker to provide some research that could be helpful to them and

to us both.

They have under construction a fairly large 2-story structure not adjacent to the plumbing high-rise tower building but not far away which will be for the expansion of research in plumbing. This will be available by the early part of 1970. This will give them more capability for setting up additional test apparatus and to permit them to revise their space which is crowded due to the limited facilities which they presently have. I have obtained back reports that cover most of the research projects so my report basically hits the highlights of their program and the vertical test facility in more detail. These reports were given to the BRD plumbing staff.

The high-rise plumbing laboratory vertical test facilities has 8 floors and each floor has both plumbing and fire research vertical test capabilities. Floors in the tower structure are approximately 8 meters by 8 meters. I have obtained a floor plan of one of the upper floors which is in reference 6 which gives a better idea of its cross section. It took them 2 years to set up apparatus in this vertical test facility and they are now in the position where they are taking some reliable data from the facilities. However, as I mentioned before they have had limited dollars in research so they have not used this facility as much as they would like. The vertical structure includes an elevator which is a combination passenger and freight. The instrumentation console and control

room is on the ground floor of the structure.

In the basement they have the supply tanks with the constant head recirculating system and for water heating equipment for the hot water system. In the basement they also have pressure control systems for cold water. On the top of the tower structure there are two constant head gravity tanks, one for cold water and one for hot water. At several levels there are booster heaters to maintain desired hot water temperatures to counteract heat losses. Permanent risers are provided in the test tower for water, compressed air and gas. They have on each floor a bath tub, two laboratories, two water closets and a bidet. The size of the floors appears to be the right size to permit them to make different bathroom fixture arrangements to get different lengths on the piping within the branches on each floor. (The test facilities floor areas at CEBTP were limited and did not have this capability.) The exterior panel walls of each floor gives good natural lighting as well as a nice architectural appearance to the entire structure. As I indicated before, on the ground floor there are two console units and an indicator panel. One of the console units permitted the pre-selection of any desired combination in sequence of fixture operations on a test stack. And the other comprised of 30 channel recorders. They did not have the funds to provide a data acquisition system with punched cards or other type of recording media. The operation they presently have, takes

a few hours to record and read the results that come out of the present recorder. Indicator panel has an illuminated diagrammatic description of each floor indicating the fixtures. It indicates when the fixture is flushed and when it is filled , which gives them a good diagrammatic indication for operating the equipment. They have automatic features where they can change the floors, the time sequence between flushings and numbers of combinations.

It would be helpful to any new young professional that we bring into BRD, for them to spend some time at CSTB and CEBTP. They could obtain considerable training from top French professionals who have had good research facilities. Joint BRD and CSTB plumbing research projects should also be considered.

TOPIC NO. 8 COORDINATION

CSTB:

On Thursday, November 20, afternoon I started my first meeting with Dr. Blachere on the U.S./French Cooperation Program. The first part of the afternoon was devoted to the visit to the United States and we made agreements on various topics.

The French team would visit the United States on January 18 through February 1. They would probably leave on Saturday the 17th, and would be leaving on February 1 which is a Sunday. It was not certain whether Dr. Blachere would come or not but it sounded like he might. We had to make quite a revision to the programs on the six subjects that we had furnished earlier. In general though the schedule would be as this. The first two days, the 19th and the 20th, would be devoted to NBS, HUD and any other Federal agency briefings that we may want to have in the Washington area. The 21st, 22nd, and 23rd would be the complete team traveling to mobile homes projects. This would probably include one factory, and two and three sites or maybe two factories. This then takes up the first full week of the team. This would leave Monday through Friday, 26, 27, 28, 29 and 30, for the five topics and be broken down into various team members. Friday, the last day, at some time would be devoted to a debriefing session at NBS with

possibly two members of the team. They would make their own reservations for travel back and forth from France to the United States. They would like for us to make the reservations for the hotels and the transportation within the United States. They suggested that we work through Cook's, American Express or one of the travel agencies.

Dr. Blachere is very much interested in doing something in climatology and when I mentioned our Environmental Engineering Section and Dr. Kusuda, he felt that maybe he would drop computers and add climatology which they are doing some work on at CSTB.

On Friday, the 21st, I spent some time again with Dr. Blachere to get into the guest worker area or the exchange of guest workers between the French and the U. S.

There are three subjects that they are apparently very interested in our participation in the guest worker program. One is the aging of plastics, and another is climatology regarding environmental engineering and the third is the transmission of noise through structures. They are interested in these three particular projects because they have just, or will be moving into very shortly, their two laboratory annexes, one in Grenoble, where they currently have six people. At that location they will probably do some work in aging of materials and climatology. They would also do some work there on a nearby military base in the sonic boom program which may be of interest to us. This is located in the French Alps and is adjacent

to a large university. It is near Lyon which has an engineering school.

At Nantes, another auxiliary laboratory, there are presently 10 people who will be expanding into new facilities and they have a project there that they are working with the United Nations that they would get involved with. It is a project they are proposing, regarding hurricane information for structures which could be similar to Dr. Pfrang's work in the structural laboratory.

In discussing the general concept of the guest worker program, it was agreed that both countries would pay their own salaries. There is some difference in salary scales between ours and theirs. They are talking about a 21 year old French employee his salary would be roughly around \$7,000 a year which is considerably less than ours, so any exchange would have to be on a salary each one paying their own salary in the other country. They would supplement their French employee's salary work in our country which would be similar to the other guest workers we have at NBS.

He indicated that we would have to find housing for the employee. We should send a letter of information or cost sheet similar to that we provide for other guest workers.

In Paris the housing may be critical. In talking with the State Department and Dr. Blachere, in the downtown the rental will run about \$200 a month, outside of Paris in the

southern area, it will run about \$160 a month for an unfurnished apartment.

Allan Greenberg at the State Department furnished information on schooling and other things in the Paris area, for our employees. A copy of the materials is in the BRD file.

We discussed the insurance program, finding out from the State Department that our employees will be fully covered in France and that there are medical facilities in the Paris area that could be used by our employees. The French may have to pick up some separate coverage. The time of the guest worker would probably be one or more years according to Dr. Blachere. Each one would pay their own transportation. I assume that we would also give our person some blanket travel orders for travel within the area for the year's period and give him some freedom with certain dollar limitations.

CEBTP:

On Wednesday, November 26, I met with Dr. Robert L. L'Hermite at CEBTP in his Paris office at 12 Rue Brancion. In discussing the U.S./French Cooperative Program he was very nonreceptive to the concept. I referred L'Hermite to Dr. Wright's letter of May 29 regarding the topics of the visit of the French to the United States and he remembered, but had no comment.

He was not interested in joining in the January visit with Dr. Blachere but did indicate that he was working up a

program for a trip in April or May when he would take some 20 contractor people to the United States for a possible three weeks tour similar to what we did with the Russians.

CEBTP was only interested in the contractor's view of the research problems. He was interested in bringing this group to the United States to look at building construction methods and possibly new materials. He indicated interest in Chicago, San Francisco, and the Washington/New York area. He said he would write us of the dates and the concept that he has and would appreciate any assistance we could do and help him work the program out.

I did discuss with L'Hermite the concept of the future guest workers at CEBTP and that we had some interest in soils and foundation work and plumbing. He apparently would be agreeable. He definitely would want to be more involved in the details of the project and what they actually were to accomplish. I indicated that when we did get into details we would be in touch with him. The French and U. S. Government should set up one person or agency to coordinate all activities.

L'Hermite had questioned if they would have anybody that they would want to send to the U. S. for an extended time. There is a problem in getting people that could do the research in the United States. He questioned the year's period as too extensive.

In further discussion with Mr. Fickleson (L'Hermite's assistant) I was informed that they do have guest workers from other countries at the CEBTP and it would be no problem for NBS.

Housing is readily available at the laboratory site where our people would be working. Possibly, it is something that we would have to work out in more detail later.

CEBTP has partial structural and materials laboratories in Paris Headquarters that they eventually will move out to their South Paris laboratory site once these are available.

After touring the laboratory in Paris I went out to their laboratory site South of Paris at Saint-Remy-Les-Chevreuse. This is located some 32 kilometers from Paris. You can travel by metro which takes approximately 40 minutes. The site is a campus type facility on an old estate, very picturesque with very good laboratory facilities.

I visited the scale model laboratory, structural laboratory, the acoustics laboratory, the mechanics and soils laboratory, concrete laboratory, and the high-rise plumbing facility. These are all fairly new facilities and very well equipped. The structural laboratory was very impressive.

The acoustics building is a new 2-story structure. They are doing sound transmission tests on exterior panels, interior walls, plumbing and doors and windows.

The heating, ventilating, and piping laboratory is a 2-building complex of 2 stories each. They have one large laboratory about the size of our largest environmental chamber. Most of their work is on heating, ventilating, and only a little on air-conditioning. They have one small chamber

they have built for testing and evaluating window air-conditioning units.

The plumbing tower facilities were very impressive. They have 17 floors in the high-rise structure. The tower structure has an elevator, a stairs, and two chases. They also have a separate small office building and computer room structure of one story. This is a new installation. They are doing hydraulic evaluations, fixtures evaluations, and some noise work on plumbing.

They also have an electronics building (that I did not visit). They have an outdoor structure for evaluating piles, and another structure for doing research on foundation retaining walls.

A lot of CEBTP work is on public work type structures such as dams, roads, and bridges. Being a general contractors research facility they have a need for doing this type of work. There appears to me to be some overlapping here between L'Hermite's operation and Blachere's operation.

2.7 T. E. Ware

Topic 2. Assessing the Quality of Buildings

REPORT ON

U.S./FRENCH COOPERATIVE PROGRAM ON BUILDING TECHNOLOGY

by

Thomas E. Ware

Assistant Chief
Building Systems Section
Building Research Division

TOPIC NO. 2 ASSESSING BUILDING QUALITY

A. Background and Scope

The rebuilding that followed the end of World War I and the building that preceeded World War II in France was traditionally achieved. New materials were use/time tested and their acceptance was, therefore, slow. Architects were trained to preserve the aesthetics of the grand style. The predominance of traditional materials and the traditional styles precluded any significant innovation in building technology. This form of romanticism did not provide for the needs of the people. Following the end of World War II in France, the situation was similar but more demanding. Clearly it was an opportunity for a new approach, a rational approach.

Four major factors in the French building industry have created a need for a rigorous method of assuring quality in the planning, programming, design, and construction of buildings.

These factors are:

- The use of new industrialized building systems.
- The introduction of new building materials and new construction techniques.
- The non-technical education of the architect in the Ecole des Beaux Arts and his limited role as an "artist" in the building process.
- The lack of skilled labor and the importation of foreign unskilled labor.

Further, it is the aim of the French government in their building programs and the aim of some private building programs

to provide good buildings, comfortable in terms of the inhabitant user, and physically durable, within a budget. There seems to be an awareness that in the past decisions were made about these aims on a very subjective basis and that a more objective basis is needed now if they are to be successfully attained.

The French building industry is fragmented and it seems those participants throughout it who are concerned with achieving quality with the new building systems and making the industry function more cohesively and more efficiently believe that a common form which develops decision information and displays it in a usable way in all phases of the building process is an appropriate effective mechanism.

B. Program

This information display-decision making form is well researched, advanced in development, coordinated with the industry, tested in use, and being revised and updated.

The program is called "Methode Systematique, d'analyse et de programmation pour la conception architecturale et la description des ouvrages."

Its use in the building process is intended to be pervasive, but not comprehensive. It is recognized that not all information necessary can be developed objectively, but that each phase and step in the thinking-building process has

a part which is capable of objective, logical development.

That part of the process not capable of objective determination is attributed to the "normal" condition that many decisions are appropriately subjective.

The program concept is developed generally as follows:

Once the building to be built and its site are determined, generic characteristics implicit in that determination, e.g., newtown low income subsidized apartments, rural elementary school, etc., are understood. The steps in the Methode then are designed first to take these implicit characteristics at the general level and make them explicit from the user's point of view and then to derive explicitly in a hierarchy of detail all the essential characteristics, not only for the user, but for all the participants in the particular building project through to the description of the final product. To facilitate this, the Methode divides the building project into three main categories:

- The first covers the program design concept formulation phase and is called the Synopsis. It is analytical.
- The second covers the design concept determination phase and is called the Inverse Synopsis. It is the synthesis.
- The third covers the description of the design in detail, the conditions of the contract, the estimate of costs, and the breakdown of work and its scheduling. It is the documentation phase.

As an example, the first phase, the analytical Synopsis clearly shows the development of the Methode. It is further divided into 3 parts--site and climate, building habitability, and the economics of the durability, maintenance, and operation. Building habitability is illustrated here.

Each part builds up layered matrices in which the "z" axis represents "organic" built elements--a matrix sheet for each--and the "x," "y" axes are needs and use. Trade-offs and reconciliation between need/use intercepts of different "organic" built elements are handled unsystematically "as needed" and objectively "if possible."

For each "organic" built element, the information is developed thus:

0 (EXAMPLE) (EXTERIOR) (WALL) "organic" built element	1 What is supplied from the site	2 What does the User require on the building	3 What op- tions reconcile the dif- ference	4 Technical justifi- cation for each option	5 What other built ele- ments could be affected
	70 db ambient noise level	25-30 db bedroom ambient noise level	40 db ex- terior wall	laboratory HVAC air experiment intake no. _____	
		30-35 db living room ambient noise level	30 db ex- terior wall	laboratory HVAC air experiment intake no. _____	

On the needs ("x") axis:

Column 0 identifies the "organic" built element to be analyzed. The French term for this element is organe. Loosely, translated, it is a component part of a building, which may connote an arbitrary subdivision. Because the French conceive of the building as an organism ("a complex structure of inter-dependent and subordinate elements whose relations and properties are largely determined by their function in the whole."--Webster), the term organic ("forming an integral element of a whole"--Webster) built element has been used. The organic built elements for this building habitability part of the Methode are:

- The whole
- The foundations
- The site as a part of the building
- The structure
- The roof
- The interior organization (planning)
- The exterior wall
- Surface treatments
- Miscellaneous

The example illustrated here is for acoustics. Others might be for ventilation, thermal conductivity, sun protection, fire protection, view, passage through, etc.

Column 1 identifies objective (illustrated) and subjective needs.

Column 2 identifies the conditions required by humans (the user illustrated); nature--the laws of physics, chemistry, e.g., for site work angle of natural soil repose; technology;

budget; and schedule. The emphasis is on the first two. Standards for human requirements are set by the Documents Techniques Unifies--D.T.U. (the French government agency roughly equivalent to the National Bureau of Standards) with the aid of work done by C.S.T.B. and others. These standards, published in report form, are summarized by D.T.U. and issued as a simplified catalogue of requirements (R.E.E.F.--La Recueil pour l'Étude et Execution des projects du Bâtiments) to architects and engineers for use in the design of buildings.

Column 3 identifies existing hardware solutions that will solve the problem stated by 1 and 2. Only one solution is illustrated; however, multiple solutions are more appropriate. Numerical, verbal, or pictorial solutions in any combination necessary to describe a solution are acceptable.

Column 4 identifies the scientific or logical justification for the selection of each solution in column 3.

Column 5 identifies other built elements or parts of built elements that may contribute to, constrain, or be an integral part of the solutions identified in column 3.

On the Use ("y") axis:

The description of the functioning of the "organic" built element from the general to the particular is listed in terms of:

its primary purpose as that is demanded from the category that represents a supply of the next highest need to be met (as illustrated).

This is amplified by its relation to the specific principal and secondary particular points of support.

Secondly, its relationships internal and external are innumerable.

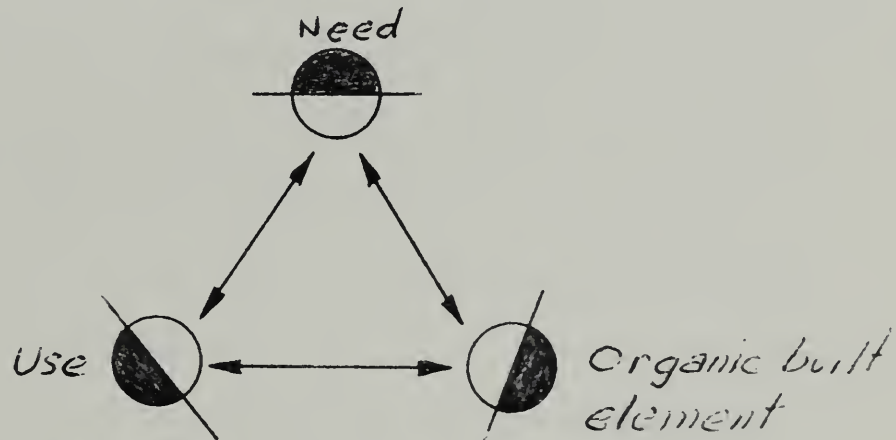
Thirdly, its interdependence externally is particularized.

Fourthly, its internal relationships--intradependence--are particularized.

Lastly, the anticipation of the life cycle requirements are stated.

These descriptions of function or use are in the form of extensive check lists; one for each "organic" built element.

The information required to develop the Methode may be diagrammed thus:



C. Program Evaluation

The need for a "design methodology" to aid in meeting the demands of a rapidly evolving technology and new socio/economic pressures is readily apparent. To be effective, however, a design method needs to be independent of building process activities and sequence in the programming, and design concept

formulation phases, where these are analytical; dependent on the activities only in a generic building process in the programming, design concept formulation, and design concept determination phases, where these are synthetic; and dependent on the sequency of activities in any particular building process in the documentation phases.

The Methode Systematique provides a very practical program based on specific existing French problems. When used under the least desirable circumstances, it assures an acceptable level of success. When used under the most desirable circumstances, it can inhibit success. (The larger interdisciplinary building teams use it only as one of many references). In the middle ground, its use could easily be perverted to a means for a rationalization of Mediocrity because its structure precludes a clear separation of objective and subjective information. With its concept built around existing hardware and hardware configuration, materials not radically different from the "newer" traditional materials, and traditional building process participants, it is unlikely the Methode has the flexibility to adapt to extensive change in any of these areas, as it is now conceived.

D. Implications for Guest Worker Program

In the United States, the design methodology today is

an unstructured part explicit, part implicit, mystique of objective and subjective information explained as "good practice," functioning primarily because educational curricula and practical experience are overlapping for the different disciplines participating in the building industry.

Implicit in the application of any new technology to a real building project is research on the building process to some appropriate level of detail. Inherent in any research work done on the building process is research on design methodology.

To date, research on design methodology either has been neglected as a practical aspect of the building process or has been researched in isolation as a socio/psychological process.

As technology develops products requiring new building processes, and as a changing educational curricula reorients participating disciplines, the need for an explicit design methodology increases. There is definitely a need for design method research in the United States as a part of building process research done well in advance of major change in building technology, and before reorientation of educational curricula becomes divergent and diffuse, as a means of providing rational new concepts at the threshold of the art for implementation in the building industry. In its ultimate use, the design method part of the building process pervades

the entire spectrum of the building industry. It is, therefore, relevant to codes and standards, enviro/behavior, and building systems particularly.

The fit between the existing French situation and program and the United States' situation and need is difficult to determine because the United States has not been investigated to the same degree as France.

In this context, then, there is a limited promise for cooperative activity until more investigation identifies the scope of the problem in the United States.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 General

The conclusions and recommendations reached by the team members are listed in their individual reports (section 2.3 through 2.7). The conclusions and recommendations reached as a team are contained in sections 3.2 and 3.3 respectively.

3.2 U. S. Team Conclusions

- a. Both countries have a great number of common problems in building technology that could benefit by a cooperation program.
- b. Each country has some research programs and facilities that the other does not have which could be shared to avoid duplication of efforts.
- c. Each country has a number of new programs (such as wind loads) which required considerable development that should be available to the other country in initiating similar programs.
- d. There is a great source of written information in both countries that is not being exchanged.
- e. There are a number of experts in certain areas of technology in each country that should be available as consultants.

- f. There is a considerable similarity between both countries in the design and construction process of acquiring buildings. However, there are some areas such as in construction contracting, unions, agreement system, labor practices, and legal aspects that cause some differences.
- g. Future U. S. Team visits to France should consider both countries expanding the topic coverage into other European countries.
- h. France has more in-depth physical capability than NBS in: plumbing, structures, acoustics, soils and foundations, and fire research.

3.3 U. S. Team Recommendations

- a. Recommend that exchange teams visit each other once or twice a year (2-week trips). This would be separate from exchange workers or joint research on certain programs. Some topics for the next U. S. visit could be:
 - 1. Information Systems
 - 2. Environmental Engineering
 - 3. Materials (roofing, flooring, etc.)
 - 4. Building Acoustics (new labs being developed in France and U. S.)

5. Electrical Systems in Buildings
6. New Town Planning (HUD)
7. Codes and Standards
8. New Structural Design Methods

b. Recommend immediate agreement on certain joint research projects. A person would be assigned from each country. The people would exchange directly on development and execution of project. Could be one to five year program with one to two month visits a year in each country. During visits the two would also consult with other CIB members in other countries. The final report could be a joint effort. Projects in the following programs fall in this category:

1. Wind Loads on Structures
2. Environmental Engineering
3. Plumbing
4. Fire Research
5. Durability of Materials
6. Building Acoustics
7. Process for Evaluation of New Building Systems, Components, and Materials
8. Building Economics

- c. It would be desirable to have young professionals who are new to CSTB or NBS in new programs to spend a number of months in the other country that has a strong technical capability.
- d. Long term guest worker program would appear desirable. However, at this time it may be impracticable because of personnel ceilings and funding limitations for U. S. to send workers.
- e. NBS has to have additional funding from Department of State or Department of Commerce for carrying out this program.
- f. Department of State should provide NBS with more specific policy on other agency participation in the program and how interagency coordination will be established.

4. FRENCH TEAM VISIT TO U. S.

The topics and dates for the French Team visit to the U. S. were completed in December 1969. The French team was scheduled to visit during the last two weeks in January 1970. The study topics and NBS personnel responsible for developing the detailed agenda for each topic are shown below.

1. Program Coordination	Harry Thompson
2. Mobile Homes	Russ Smith
3. Urban Acoustics	John Halldane
4. Climatology	Frank Powell
5. Fire Research	Irwin Benjamin
6. Economics of Single Family Housing	Tom Ware
7. Plastics in Buildings	Gene Gray
8. Light Weight Construction	E. V. Leyendecker
9. Performance Specifications for Office Buildings	Bob Blake

The French team will consist of:

Mr. Gerard Blachere, Director, C.S.T.B.
Mr. Charles Noel, Chief, Economic Services
Colonel A. Cabret, Chief, Fire Services
Mr. R. Josse, Chief, Acoustics Division
Mr. E. Farhi, Chief, Organic Products Division
Mr. J. Berthier, Methods of Construction Division
Mr. J. Borel, Thermal Design Division

The time spent by each team member on study topics is shown in figure 4.1.

Figure 4.1 FRENCH ITINERARY

French/U.S. Cooperative Program Building Technology

First French Team Visit to U.S.A.: January 1969

NAME	First Week							Second Week							Topics
	M	T	W	T	F	S	S	M	T	W	T	F	S		
	19	20	21	22	23	24	25	26	27	28	29	30	31		
G. Blachere	X	X	2	2	2	--	--	3	4	6	9	1	--	1. Coordination G. Blachere	
C. Noel	X	X	2	2	2	--	--	6	6	6	6	6	--	2. Mobile Homes Team	
R. Josse	X	X	2	2	2	--	--	3	3	3	3	3	--	3. Urban Acoustics R. Josse	
J. Borel	X	X	2	2	2	--	--	4	4	4	4	4	--	4. Climatology J. Borel	
A. Cabret	X	X	2	2	2	--	--	5	5	5	5	5	--	5. Fire Research A. Cabret	
J. Berthier	X	X	2	2	2	--	--	8	8	8	8	8	--	6. Economics of Single Family Housing C. Noel	
E. Farhi	X	X	2	2	2	--	--	7	7	7	7	7	--	7. Plastics in Buildings E. Farhi	
X NBS/HUD Briefings														8. Lightweight Construction J. Berthier	
														9. Performance Specifications for Office Buildings	

APPENDIX A

Descriptions of U. S. Team Topics 1-7

Topic 1: ECONOMIC APPRAISAL IN BUILDINGS (prepared by CSTB)

The price of a building is contingent. Besides the actual consistence of a building providing the required facilities is different, following its geometry and the variety in number and quality of equipments and finishings.

These circumstances make rather woolly the relationship between price and usefulness.

CSTB has developed a yardstick system which enlightens these various points:

- "A.R.C. method" for quick cost estimation
- "+ and - method" for appraising what the useful parts of the building consist of. Conclusions have already been elaborated from the use of these tools.

- Reading :
- "Savoir bâtir" by Ing. G. Blachère
 - "A.R.C. (Méthode d'analyse raisonnée et d'appréciation rapide du coût de construction" Cahiers du CSTB n° 818 Livraison 94.
 - "Examen de la qualité des projets de construction de logements d'immeubles collectifs". Cahiers du CSTB n° 868 Livraison 100.
 - "Examen de la qualité des projets de construction de logements d'immeubles collectifs". Exemple d'application. Cahiers du CSTB n° 890, Livraison 102.

- Program :
- 2 days conferences in the CSTB, Paris with the Economics Department of CSTB.

Topic 2: ASSESSING THE QUALITY OF BUILDINGS (prepared by CSTB)

A building should meet the user's needs as described in the explicit programme for a given construction as well as in the implicit and general programmes covered by generic names such as "dwelling", "school", "hospital", etc...

A logical path to realize this satisfaction begins with the explicitation of the implicit programme, i.e., working the general human needs or requirements in dwellings, schools, etc...

It goes on by providing sufficient knowledge to build up solutions to a given case and to check them, and useful technical documents translating science to the level of practioners such as standards, calculation rules, codes of practice and even by-laws and regulations.

Special attention must be devoted to the acceptance of new systems and materials: The agrément system is an answer.

It is practical to write first the general lines of the solutions, then the solutions chosen for every part of the construction, including what is related to the boundaries between components. It is the aim of the "1st and 2nd synopses".

From these synopses it is possible to draw the detailed description of the building and of its parts.

- Reading : - "Méthode systématique d'analyse et de programmation pour la conception architecturale de la description des ouvrages" Cahiers du CSTB n° 843, Livraison 97.
- "Savoir bâtir".

- Program : - 2 days conferences in Marseille with the Permanent University of Architecture (UPAU)
- 2 days conferences with CSTB Economics Department.

Topic 3: AGRÉMENT SYSTEM AND FULL-SCALE TESTING

(prepared by CSTB)

In order to promote a quick and safe spreading of the use of new materials and systems, it is better to use a procedure giving a valuable assessment of the aptitude for use of the products and methods making the producers sure of the acceptance of the product by every authority and user and giving the users a reliable guarantee of safety.

In this prospect, CSTB has developed an examination and trial procedure based on full scale or laboratory tests, with the participation of all interested parties: producers, architects, contractors, engineers, public authorities, etc...

The system, today is spreading over Europe.

Reading : - CSTB reports.

Program : - Visit of the different CSTB Research Station departments: 5 days.

Topic 4: ADVANCEMENT OF BUILDING APPLIED SCIENCES

(PSYCHOLOGICAL AND SOCIAL) (Prepared by CSTB)

The theme is the survey of the research of the physical and human sciences applied to building, mainly: acoustics, hygrothermics then lighting, sociology, psychology.

Reading : - CSTB publications

- and others.

Visit : - 4 days - CSTB Research Station

- UTI (Union Technique Interfederale du bâtiment et des travaux publics)
Research Station.

Topic 5: INDUSTRIALIZED BUILDINGS (Prepared by CSTB)

French contractors and engineers have been developing for 15 years many industrialized systems of construction of multistorey buildings.

The production of these systems is very important: more than 100,000 dwellings every year - and the total number since the origin is above the million.

Such systems are essentially concrete or brick and concrete systems, including plant or site prefabrication or industrialized production in place.

Light systems are also in use as well as special systems for one family houses.

Suggested reading : - CSTB reports

Program : - 2 weeks of visits through Paris and France.

Topic 6: SOIL MECHANICS AND FOUNDATIONS (Prepared by NBS)

The Building Research Division does not have a program or facilities to do research in soil mechanics and foundations. However, most structural failures in buildings are attributable to foundation problems. Foundations currently account for approximately 20% of the total structural cost of buildings. The expansion of our population in urban areas causes an increased demand for building sites and an increasing scarcity of building sites with favorable foundation conditions, thus further raising the cost of foundations and increasing the chances of foundation induced problems. The science of soil mechanics and the art and science of foundation design have made great strides in the last decade, however, foundation design is still basically empirical and large margins of safety are used to compensate for uncertainty in judgment. Building codes related to foundation design are extremely conservative and in general have not caught up with the state of the art. Any advance in the state of the art of soil mechanics and foundation design and any improvement in existing codes will not only decrease construction cost, it will also prevent costly and dangerous structural failures.

The proposed program in soil mechanics and foundation research to be initiated at BRD will have the following

objectives:

(a) Basic research in soil mechanics (strength, load bearing characteristics, consolidation and drainage).

(b) Research in the physical and mechanical properties of soils including corrosive effects on structures.

(c) Basic research in the field of soil classification (setting of standards).

(d) The use of soil as an engineered construction material (compaction, etc.).

(e) Research on dynamic and seismic effects on foundations.

(f) Performance specifications and performance codes for foundation.

(g) Research in advanced methods of subsurface exploration.

The following benefits can be expected from this research program:

(a) Reduction of the cost of structural foundations and subsurface exploration.

(b) Reduction in the number of structural failures due to foundations.

(c) Introduction of greater uniformity in the professional practice of foundation design, in soil classification and in building codes.

Visit in France: - (Discuss programs and visit laboratories)

- Five days - CSTB Research Station

- UTI

Topic 7: PLUMBING SYSTEM AND RESEARCH (Prepared by NBS)

The Building Research Division, as well as the building industry, has very limited facilities in plumbing research with no facilities for doing research in high-rise plumbing. Plumbing code requirements are written in terms of the properties of materials rather than the hydraulic, pneumatic, safety, and durability requirements for all such systems in relation to the size and type of application under consideration.

Reliable and comprehensive data on the waste loads to be accommodated in relation to number of families, fixtures, building levels, etc., to be served by a plumbing system is lacking. The growing construction of high-rise residential and office structures and the advent of automatic washers, dishwashers, garbage grinders, and foaming detergents have altered the hydraulic and pneumatic phenomena since the load data now in use were obtained a number of years ago at BRD.

In any effort to improve the functional effectiveness and lower the cost of plumbing systems as well as make an important contribution toward overcoming the "codes and standards controversy," it is essential to obtain data on low-rise and high-rise buildings of current design with respect to:

- Hydraulic and pneumatic flow rates and pressures at critical points in drainage and venting systems.
- Time distribution of plumbing fixture and water-using equipment usage.
- Hydraulic demands on main and branch water-supply pipes.
- Hydraulic and pneumatic performance of water-supplied plumbing devices and fixtures, including food-waste disposal units, automatic dishwashers, automatic laundry machines, and conventional plumbing fixtures.

Visit in France: - (Discuss programs and visit laboratories for possible assignment of BRD guest worker in France)

- One day - CSTB Research

- UTI

APPENDIX B

DESCRIPTION OF CSTB (in English)

Scientific and Technical Center of Building (CSTB)

Address: 4, avenue du Recteur-Poincaré, Paris (XVI^e).
Tel.: 288.81.80

Research Station: avenue Jean-Jaurès, Champs-sur-Marne,
(Seine et Marne). Tel.: 957.32.58

Legal Form: Public foundation of an industrial and commercial
character (decree of September 30, 1953).

President: Mr. Raymond Pabanel.

Director: Mr. Gérard Blachère, Chief Engineer of Bridges
and Roads.

Purpose: Progress in construction and housing by the
development of productivity, the improvement of
quality and lowering of the cost of construction.

Characterizing the CSTB is its public character,
related to a strong contact with the building
professions, whose representatives constitute a
majority of its board of directors and participate
in all its committees. The CSTB's technical
production is thus divorced from particular
professional interests, and yet takes into account
technical and economic factors as well as the
general interest.

All the CSTB's activities are carried out for the
benefit of the Administration, to which the CSTB
furnishes all written regulations and circulars of
a technical character: building regulations,
decrees of enforcement, technical specifications
for State-aided construction, etc.

Its activities are also carried out for the benefit
of builders, as follows:

- approval of new materials and building processes;
- advancement of building science in its 3 parts:
establishment of functional requirements,
establishment of natural data, knowledge of the
sciences, as such, in order to establish rules
of quality applicable to the various building
elements;

- participation in studies of productivity, especially the productivity attributable to directors of work and to the Administration, as well as to the improvement of the appreciation of quality.

The CSTB makes the results of its work available to the public by means of the publication of a periodical, the CSTB Notebook, subscribed bi-monthly, and of an annual volume of about 2000 pages, the Handbook for the Study and Execution of Building Projects, the R.E.E.F. 58, containing, in particular, the review of building sciences, and the Catalog of Building.

The CSTB has at its disposal significant library and documentation service.

Staff : - 324, as follows:

Management: 10
Researchers and engineers: 92
Technicians and draftsmen: 64
Laborers: 57
Administrative personnel: 101.

Budget : - Resources: provided by a State subsidy and its own resources.

- 1966 expenses: 16,809,000 francs, including:
 - Operation: 14,309,000 francs
 - Investments: 2,500,000 francs

RESEARCH PROGRAM
Scientific Divisions

Acoustic Division

Acoustical study of the elements of construction.
Measure of the acoustic efficiency of flooring materials
under the effects of walking.

Research on acoustic insulation in housing, particularly
related to impact sounds and equipment noises.

A study for improving present standardization; especially
in the field of impacts; effects of heavy impacts.

Noise in the vicinity of highways.

The correlation between exterior noises on the one hand,
and the prevention of sleep, and psychological and
physiological disturbances, on the other.

The validity of criteria for acoustical quality in
housing.

Sound transmission through exterior walls.

Lighting and Colorimetry Division.

Methods for design of natural lighting and of interior
artificial lighting.

Human needs regarding lighting.

Sunlight.

Natural lighting as an aid to natural [artificial ?-- transl.] lighting.

Air Pollution Division

Study of air pollution in 26 communities in the Paris region.

Study of air pollution in 3 monitoring points in Paris.

Study of air pollution at each level of the Eiffel Tower.

Human Needs Division

Study of areas bordering on highways, relating to annoyance caused by motor traffic noise.

Experiments on real housing.

Hygrothermal and Ventilation Service

Building Thermal Design Division

Summer comfort in lightweight school construction.

Use of roof insulation for thermal comfort in a dry tropical climate.

Thermal characteristics of ventilated roofs.

Air conditioning by humidification or by refrigeration in a dry tropical zone.

Heating of dwelling rooms. Flexibility required for the installation of heating.

Study of a prototype apartment building heated by electricity.

Thermal Data, Characteristics and Calculations Division

Human needs for thermal comfort.

Thermal characteristics of materials and workmanship.

Realization of an electric analogue machine for the solution of problems of a variable thermal environment.

Determination of basic exterior temperature and basic interior temperature for the calculations of thermal losses.

Ventilation Division

Characteristics of self-regulating air intakes, of natural ventilation ducts, of static ventilators and of mechanical air exhaust systems.

Waterproofing of Joints Sections

Waterproofing of exterior walls.

Flow of water on vertical surfaces.

Characteristics of driving rain.

Climatology and Natural Data Section

Summary and classification of climatic data.

Study of the sequences and types of weather.

Service of Approval (agrément) and of the Studies of Materials and Processes of Construction

Hygrothermal Division of Materials

Measure of thermal characteristics of materials and elements of construction.

Construction Processes Division

Study and general research on non-traditional materials and processes submitted for approval.

Studies of the strength of non-reinforced concrete walls and of masonry walls, for the purpose of developing rules for the calculation of masonry. Horizontal joints between structural elements of heavy prefab construction.

Tests for carpentry.

Organic Products Division

Behavior of thin flooring materials in school-rooms.

Natural tests of plastic flooring submitted to a traffic characterized by slow steps with stops, pivoting and trampling.

Cracking and waterproofing.

Natural aging of jointing materials under the effects of mechanical action.

Mineral Materials Division

Lightweight concrete.

Thermal treatment of concrete by heating its constituent parts.

Thermal treatment of concrete by heated formwork.

Surface Protection Division

Weathering resistance of protective finishes for metals used in construction.

Weathering resistance of paint and thin coatings for exterior walls.

Specification and Standardization Service (C.N.C.)

Systems for water evacuation in housing.

Plastic piping for the evacuation of used water.

Behavior of P.V.C. non-plastified pipes cast in concrete,
under warm flow.

Assembly of pipes by gluing, fitted joints, ties,
welding.

Water valves and heating valves.

Sanitary fixtures.

Coverings: [drain ?--transl.] tile and [lay-in ?--
transl.] tile; corrugated plaques of glass fiber reinforced
polyester; waterproofing of coverings.

Surface condition of paint specimens, etc.

Service for the Studies of the Effects of
Fire and Fire Prevention in Building

Smoke-clearing of public circulation spaces of a
building in case of fire.

Test methods for the fire hazard of electric wiring.

Behavior in fire of roofs submitted to an external fire.

Tests "in the box" for the combustion of wood structures.

Fire development in a dwelling room.

Smoke emitted by materials during a fire.

Service for Production, Industrialization,
Regulation and Program Definition (P.I.R.P.)

Cost analysis according to the nature of its component parts (breakdown).

Variation in construction cost as a function of various project design parameters. Typically dense construction.

Variation of prefab panel unit prices as a function of their dimensions.

Methods of work organization (scheduling).

Variation of work unit prices according to the importance of the series [type of work ?--transl.].

Methods of National analysis and of rapid escalation of construction cost. (A.R.C. method).

Improvement of the method of quality escalation.

Studies of the application and demonstration sites.
Site of 400 urban renewal apartments at Creusot-Torcy
(experimental program of the high authority of C.E.C.A.).

Tropical Section

Study of the totality of tropical construction problems.

Editing a tri-monthly publication, Tropical Building.

Special studies:

- Use of industrial thermal insulation in a dry tropical climate;
- Problems of construction Guadeloupe;
- Organization of building operation in Africa;
- Adaptation of industrialized techniques in developing countries;
- Manufacture of economical sanitary fixtures.

APPENDIX C

Examination of the Quality of Construction Projects for Dwellings in Collective Buildings

F O R M U L A E

1. GENERAL PRINCIPLES

To be able to compare a price quotation of an enterprise or a price estimate for a project with the current prices on the market at a given time, it is essential to be informed as clearly and as objectively as possible with regard to the quality of the construction offered for this price. This quality is broken down into a material content, and the degree of satisfaction of different human requirements.

The CSTB method for the evaluation of the useful content of projects was made public in April 1961 in issue n°. 388 of Part 49 of the "Cahiers" and the results of numerous content evaluations were also published along with the lessons to be drawn therefrom.

The evaluation of levels of comfort is possible for all the requirements, but is practically done only for two requirements: Thermal comfort and acoustical comfort; and for the thermal comfort requirement what is involved is only an evaluation of the thermal quality of the construction proper, without taking into account whatever has to do with the economy of heating.

We are presenting here a review of the principles used in the evaluation of useful content, acoustical quality and

thermal quality, along with a questionnaire which should be filled in by evaluation applicants, and a model of evaluation sheets which are completed by the CSTB and returned to the applicants.

The method does not include the overall evaluation of useful content, acoustical quality and thermal quality. Each field is dealt with in a separate evaluation sheet, giving details pertaining to each.

The user must make his own overall evaluation, assigning to each of the different qualities the relative weight which he considers appropriate.

2. USEFUL-CONTENT EVALUATION METHOD

2.1 Principles

The useful-content evaluation method consists of comparing the construction items of a reference dwelling unit with the items of an actual dwelling unit which contribute to its finished outfitting, i.e., the finishings, every thing which is apparent, appliances, everything which is touched or manipulated, the habitable area and the non-habitable areas, such as balconies, loggias, etc. The prices used in this comparison have been taken from a table established for this purpose. The present table, that of 1967, was drawn up by a committee which included, along with the representatives of the CSTB, the Ministry of Equipment,

representatives of building owners, quantity surveyors, architects, consulting engineers, and contractors. The quantities are lump-sum quantities the values of which are given in section 2.5.

The actual prices of the operation are not taken into account, nor is the quality of the execution, and are thus not included in the evaluation of content.

The total of items involved in the evaluation of content represents 55% of the prices of the reference dwelling-unit.

2.2 Reference dwelling-unit

DEFINITION (see section 2.5)

Number of rooms: 4 (in a building R + 4)

Habitable area: 70 m²

Non habitable area:

- Loggias + balconies + drying rooms: 0 m²

- Cellars: 3 m²

- Halls: 1 m²

- Stair-wells: 1 m²

Quality of work:

Coverings and finishings: slightly higher than the minimum values set by the C.P.T.F.M.U. (1)

CALCULATION OF USEFUL CONTENT (Po) OF THE REFERENCE DWELLING-UNIT

Quantities (q_0)

Set unvaryingly by kind of element or room (see section 2.5)

Unit prices (p_0)

Price of table corresponding to the kind of reference elements chosen (see section 2.6)

The total P_0 of the useful content is obtained by adding all the products of the quantities of the reference dwelling-unit by the reference unit prices

$$P_0 = \sum (p_0 \times q_0)$$

2.3 Representative dwelling of the operation (collective buildings)

DEFINITION

Number of rooms: 4

Habitable area:

Area of reference dwelling unit (70 m²) increased by the excess area in relation to the maximum values set per type of dwelling unit by the HLM (low rental housing)

Decree of 22 March 1958, viz:

- 30 m² (type I), 45 m² (type II)
- 57 m² (type III), 70 m² (type IV)
- 85 m² (type V), 100 m² (type VI)

Non habitable areas:

Actual areas in terms of average dwelling unit

(1) Minimum specifications for "Public housing"

Quality of work:

Actual quality

CALCULATION OF USEFUL CONTENT (P_1) OF REPRESENTATIVE DWELLING UNIT

Unit prices:

Price of schedule corresponding to the kind of work items and actual rooms.

The amount (P_1) of the useful content is obtained:

- 1) By adding all the products of the quantities of the reference dwelling unit by the actual unit prices;
- 2) By adding to this total the product of the excess areas (habitable or not) by the unit price of each of the room concerned.

This unit price is 180 F per m² for the excess habitable area. It covers the price of coverings and finishings but also the price of the structural work included in the additional habitable square meters.

2.4 Useful content

The useful content of a project is given by the difference

$$P_1 - P_0$$

The method described above concern the collective buildings.

An identical method exists for the individual houses. It includes a special schedule and the reference dwellings are broken down into types, making it possible to compare the actual house and not the "representative" dwellings unit.

2.5 Refer to Table 2.5

2.6 Evaluation of Content of Dwellings

2.6 Schedule of Unit Prices for Collective Buildings

To facilitate its use, this document, which forms a whole has been separated from the present brochure.

3. ACOUSTICAL QUALITY EVALUATION METHOD

Acoustical quality evaluation is made on the basis of the qualities recommended in the technical notice of the C.S.T.B. for the application of the building regulation.

This evaluation is done on plans and in particular deals with protection against external noise, protection against air-carried noises coming from neighbouring dwellings or traffic, protection against impact noises, and protection against noises from the operation of various equipment in the building.

These evaluations are furnished in the form of adjectives qualifying the degree of satisfaction in these different fields.

2.5. TABLE OF QUANTITIES AND UNIT PRICES OF REFERENCE DWELLING UNIT

N ^o of charac- teris- tics	Work items considered	Reference dwelling unit		
		Quantities (Col.3)	Unit price (Col.4)	Total (Col.5)
I.	<u>items counted in the ceiling price</u>			
1.	Horizontal items			
11	Floor coverings			
	Floors of wet rooms			
	Floors of dry rooms			
12	Ceilings			
	Ceilings of wet rooms			
	Ceilings of dry rooms			
	(TOTAL A)			
2	Vertical items			
21	Exterior openings			
	Windows			
	(TOTAL B)			
22	Exterior coverings			
	Breasts			
	Window piers			
	Gables			
	(TOTAL C)			
	Basement walls			
23	Interior coverings			
	On facades			
	- hab. rooms (dry rooms)			
	- serv. rooms (wet rooms)			
	On partitions:			
	- hab. rooms (dry rooms)			
	- serv. rooms (wet rooms)			
	Coverings behind applian- ces			
	(TOTAL D)			

3.	Appliances	6.	Rooms outside of habitable area
31	Sanitary appliances	61	Private annexes
	Bath		Loggias, natural dryers
	Washbasin		Balconies
	W.C.		Activated dryer
			(TOTAL K)
32	Household appliances		Total coverings+finishings + equipment + roofing
	Sink unit (cabinet)		Areas (not including cellars, storeroom and access)
	Rubbish-shoot		
33	Services		A+B+C+D+E+F+G+H+I
	Hot water (production)		Cellars
	Hot water (piping)		Storerooms
	Cold water - Waste water		(TOTAL L)
	Electricity		
	Television		
	(TOTAL E)	62	Common passages and accesses
34	Blinds, shutters		Stairwell
	(TOTAL F)		Entrance hall
			(TOTAL M)
35	Doors		Total coverings + finishing + equipment + roofing
	Landing door		Areas (including cellars, storerooms and access areas)
	Distribution doors		
	(TOTAL G)		A+B+C+D+E+F+G+H+I
4	General work items and equipment		
41	General work items	II	<u>Work items outside of ceiling price</u>
	Roofing	33	Heating
	(TOTAL H)		Lifts
5	Habitable areas		
54	Storage		
	(TOTAL I)		
	Total coverings + finishings + equipment + roofing		
	A+B+C+D+E+F+G+H+I		
	Excess area		
	(m2 over or under 70 m2)		
	(TOTAL J)		

4. THERMAL QUALITY EVALUATION METHOD

The thermal evaluation is not intended to evaluate a degree of comfort. Essential data, such as the economics of heating, occupation density and steam production rate are in fact not covered by it.

Moreover, a rigorous evaluation cannot be made of all the elements of the building and equipment. Only certain characteristics, such as the K Factor (1) may be given values and compared with required or recommended values. Others, such as heating uniformity, can only be evaluated by observation or estimation.

The evaluation is made as a function of the climatic zone, the definition of the zones being that given in REEF-58 (volume II - Chapter D5, page 28.)

(1) V Factor

4.1 Evaluation from the WINTER COMFORT standpoint

Evaluation figures are given on three characteristics of the building:

- Volume loss coefficient "G" of the whole building or of the dwelling and of the worse insulated dwelling.
The values of these coefficients provide an indication of the theoretical cost of heating and its uniformity.
- The useful heat transmission coefficient "K" of opaque walls, facades, gables, roofing, low-floors the quality of which is one of the elements of the uniformity of

internal comfort, risks of condensation and economy of heating.

- The internal surface temperature heterogeneity factor "p m", i.e., the extent of weak thermal points under columns, partitions, floors, etc... which is an important element from the standpoint of risks of condensation.

Observations and estimations are made on:

- The uniformity of heating, which influences both the uniformity of internal comfort and the risks of condensation.
- Ventilation ducts, which are important elements of winter ventilation.

4.11 Evaluation figures for building elements

4.111 Volume loss coefficient

The definition, calculation method and reference values are those given in the technical notice of the C.S.T.B. of December 1, 1958 (see REEF, volume 1 bis).

If the value of the

coefficient is:

the evaluation is:

- equal to the required on

(G to within $\pm 10\%$)

- satisfactory

- between (G - 10%) and

(G - 30%)

- good

- less than or equal to
(G - 30%) - excellent
- between (G + 10%) and
(G + 30%) - insufficient
- greater than or equal to
(G + 30%) - highly insuffi-
cient

The evaluation covers the whole building or an "average" lodging and the worse insulated dwelling.

4.112 Useful heat transmission coefficient of opaque walls

The reference values are those recommended by the C.S.T.B. for average dwellings, published partially in the Cahiers of the C.S.T.B. (No. 237, part 34) and published fully in the REEF-58 (volume II, chapter D5, page 206).

They are as follows:

Coefficieit K	Equivalent weight kg/m ²	Climatic zones
_____	_____	_____
1. FACADES of collective buildings		

2. GABLES of collective buildings and all WALLS		

3. ROOFS		
a) Flat roofs or roofs without correctly ventilated air space		
b) Pitched roof		

4. FLOORS (*)

- a) in unheated areas or on sanitary space
- b) on covered and open passage

(*) In the case of floors on earth bed or over sanitary space, the notion of K has no meaning. Sufficient insulation is however still required, in particular around the building. A qualitative evaluation will then be made.

If the value of the coefficient

is:

the evaluation is:

- equal to the recommended one

(K to within ± 0.1)

-satisfactory

- between (K - 0.1 and

(K - 0.3)

-good

- Less than or equal to

(K - 0.3)

-excellent

- between (K + 0.1) and

(K + 0.3)

-insufficient

- greater than or equal to

(K + 0.3)

-highly insufficient

These coefficients are calculated in accordance with the indications of the D.T.U. "Rules for calculating useful heat characteristics of building walls and basic heat losses of buildings" Cahier of the C.S.T.B. No. 513, part 62.

In the case of building systems heeding "agreement", it is possible to adapt the value indicated in the agreement

document published in the Cahiers of the C.S.T.B.

4.113 Internal surface temperature heterogeneity factor of opaque walls "p m"

The definition of p m and its determination method are given in the REEF-58, volume II, chapter D5, page 106.

The recommended limit values (same document, page 208) are: 1.5 in zones A and B; 2 in zone C.

If the value of p m is: the evaluation is:

<u>in zones A and B</u>	<u>in zone C</u>	
from 1.35 to 1.65	from 1.8 to 2.2	- satisfactory
from 1.35 to 1.2	from 1.8 to 1.5	- good
< 1.2	< 1.5	- excellent
from 1.65 to 2	from 2.2 to 3	- insufficient
> 2	> 3	- highly insufficient

4.12 Observations and estimations

4.121 As regards heating, uniformity is evaluated from two viewpoints:

- firstly, between the different rooms, as a function of the existence or absence of central, individual or collective heating, i.e., the presence or absence of heat (radiators, convectors, radiating panels, warm air diffusers) in all rooms.

- Secondly, in each room, as a function of the location of heat sources near or far from cold walls.

4.122 As regards ventilation, one simply observes whether or not there are any air exhaust ducts in the technical rooms, kitchens, bathrooms and W.C.

4.2. Evaluation from the SUMMER COMFORT standpoint

Evaluation figures are given of the two insulating characteristics of the outer walls: the coefficient of heat transmission of the walls exposed to the sun and the solar factor of glazed bays, representing the two elements upon which the incoming heat is essentially dependent.

An estimation is made of the surface area of the glazed bays, of the inertia of internal walls and of the possibility of areas ventilation.

4.21. Evaluation figures

4.211. Useful heat transmission of opaque walls

The evaluation of the suitability of the observed coefficient is made in accordance with the table opposite (4.112). The data of this table take into account the inertia of the walls and the ventilation of roofs.

On the other hand, no account is taken of the reflecting power of the external surface; which would be a serious omission in countries where whitewash is used as protection from the sun, but which is permissible in France.

4.212. Solar factor of glazed bays

The solar factor is equal to the ratio of the heat flux entering through the closed bay, and protected by a covering device, if one exists, to the sun rays striking the facade. The exact definition conditions, the determination method and the solar factor values of current devices are given in the Cahier of the CSTB n° 437, part 55.

Based upon the quality rule given in REEF-58 (volume II, chapter D5, page 214), the following evaluation criteria are used:

- With S and W exposure, i.e., from SE to NNW in the northern zone, and with E, S and W exposure, i.e., from NE to NNW in the southern zone:

If the solar factor is:	the evaluation is:
- less than or equal to 10%	- excellent
- between 10 and 20%	- good
- between 20 and 35%	- satisfactory
- between 35 and 50%	- insufficient
- greater than or equal to 50%	- highly insufficient

- With E exposure, i.e., NE to SE, in the northern zone:

If the solar factor is: the evaluation is:

- | | |
|--------------------------------|----------------|
| - less than or equal to 20% | - excellent |
| - between 20 and 35% | - good |
| - between 35 and 50% | - satisfactory |
| - greater than or equal to 50% | - insufficient |

- With N exposure, i.e., NNW to NE, no solar protection is deemed necessary.

4.22. Observations and estimations

4.221. Surface area of glazed bays

The surface areas are compared roughly with those recommended in REEF-58 (volume II, chapter D5, page 214).

4.222. Inertia of interior walls

The composition of floors, partitions, and dividers of dwelling buildings in France is generally such that the interior inertia is sufficient to satisfactorily attenuate the daily cycles, provided that the received heat is suitably controlled. There is thus little to be said, except in the exceptional case of extra-light interior walls.

4.223. Possibility of cross ventilation

The possibility of day and night-time ventilation on

the facades in the shade depends essentially on the existence or absence of double exposure.

Depending on this point, the regulations and builders generally provide for the double exposure of large lodgings (F II and over) and only for these. There is thus little to be said, other than noting the cases where the regulation is not applied.

APPENDIX D

ARC Method

A R C M E T H O D

(Method for "RATIONAL COST ANALYSIS")

The ARC Method is a tool invented and developed at the Centre Scientifique et Technique du Bâtiment (CSTB) for the rapid appraisal of projects, and for the analysis and comparison of costs. Its starting point is different from that of conventional quantity measuring methods which involve merely the calculation of expenses without attempting to classify them other than by groups of elements and by trades.

In opposition, the ARC Method is designed primarily for classifying expenses according to rooms or groups of rooms in accordance with the dimensions and the shape of the volumes and the kind of materials and equipment used. Each room constitutes a parallelepiped box with its own elements and its own specific equipment.

The ARC Method is above all a method for calculating the quantities of each element according to the design and the specification of element. Its use in cost evaluations or cost comparisons requires to know the unit prices of the different items. These prices are not different from those used in conventional estimating methods.

It is obvious that instead of multiplying prices by quantities, it is just as easy to apply quantities of materials

or labour, thereby permitting all "outlay" (1) estimations, often used by contractors in establishing their prices, rather than using the unit prices of the elements.

The analysis possibilities offered by the method result from the method of grouping prices, by type of room and by type of element.

In particular, the presentation of results by groups of rooms affords immediate information on the relative importance of each of these groups (habitable surface-area, loggias, accesses, various annexes) in terms of both price and surface-area. It is thus possible to change the total price by a change of the prices of the different elements, either by modifying surface-area, or their specifications.

Formulae which give the prices of the different "boxes" integrate all the geometrical characteristics of these volumes (surface-area, shape, height, number). It is easy to determine the combined or separate influence of some of these parameters in different hypothesis of unit prices. This affords a simple solution to the calculation of the value of the influence of the different parameters involved in the design of a project (2).

The accuracy of results is dependent only on the accuracy of the perimeter coefficient used for calculating the

(1) "Debourse" in French

(2) See study of Meyrat in Build International

total length of the walls and partitions the maximum error is about 1.5% of the final cost in the rapid version of the method.

The rapidity of the method depends on the desired accuracy and on the quality of the data. It is obvious that the method will afford the best results only if the data are complete and, preferably, coded. This does not at all mean that unusual data must be used: In fact in a conventional method all the required figures must be calculated as well.

Risks of error are very small if compared with conventional methods. In fact:

- the presentation of expenses by room is a check list which leaves little risk for omissions;
- the extensive use of tables and charts reduces the possibility of calculation errors;
- finally the repeated use of the method makes it possible to collect statistical ratios which constitute warnings if the figures look unusual.

Since the method does not bother about the location of a box related to the others any type of assembly of parallelepiped boxes can be estimated by ARC Method.

The algebraic formulation of cost facilitates the computerization of the method. A program has already been established in FORTRAN IV by the CSTB to be used on an IBM 1130 computer. Making this program available to the public is a subject under examination at the present time.

The ARC Method is now presented in three versions:
the basic method, the normal method and the rapid method,
which differ only in the speed of application and in accuracy
(3).

(3) See Cahiers of CSTB, n° 714 (October 1966) and n° 818
(October 1969).

USE OF THE ARC METHOD

Cost Estimation

The ARC Method offers three possibilities of estimation:

1) By element and by room (or group of rooms)

It is possible to get separate figures for:

- the horizontal items: floors, floor and ceiling finishes
- the vertical items: facade walls, gables bearing walls partitions and their finishes
- services: sanitary and kitchen, doors, etc.

These estimations may be made on the level of a single room or groups of rooms (dwelling units, staircases, accesses, private annexes, etc.)

These groups of rooms may moreover include all the rooms of a building.

2) By square meter of room or group of rooms

The price per square meter obtained depends on the dimensions, on the shape of the room and of the number of rooms if a group of rooms is involved.

As in the preceding case, the method makes it possible to calculate the price per square meter of a whole set of rooms or groups of sets of rooms. Thus, it is possible to directly calculate the average price per square meter of all the dwelling involved in an operation.

3) "Outlay" (1) of materials, labour, etc.

The method is very easily applicable to the calculation of "outlay" prices if the quantities of materials and labour per work item unit are known. One need only apply the formula as many times as there are materials; this is where the use of the computer is valuable.

In the three cases, the accuracy of the quantities varies from 1 to 2 percent depending on the number of data used (30 to 100, according to the desired degree of accuracy, of which two-thirds are incompressible data of unit prices).

The final accuracy of the prices is of the same order of magnitude, compared with a conventional estimation method, since the unit prices are taken from the same sources, (bills, schedules).

In this estimation, the risks of errors, omissions or doubling are much smaller than in conventional quantity measuring due to the fact that the presentation is a check list which must be obligatorily completed.

(1) "Déboursé" in French

Cost Analysis

The presentation of results automatically constitutes an analysis of cost as a function of the main design parameters; each term of the formulae used or the association of certain terms in fact provides the value of the essential parameters, which are:

- the structural design
- the composition of the dwelling unit plan
- the number of rooms
- the surface area
- the thickness
- the number of levels
- height under ceiling
- size of private annexes (Balconies, loggias, cellars)
- size of accesses, staircases
- size of non private
- unit prices of elements
- density of equipment

This analysis, applied to a given project, makes it possible to reveal abnormalities in the expenses attributable to these different parameters.

If this analysis is carried out early enough, it is possible to modify the project.

Comparison of Costs

This application is only a corollary of cost analysis. It may be used in three ways:

- 1) either with constant unit prices for the solutions to be compared: in this case it constitutes a comparison of designs and of architectural composition with equivalent materials.
- 2) with actual unit prices: in this case, it represents the comparison of costs, with all types mixed together, which is specially justified with the financing of low-rental housing in France.
- 3) or with actual unit prices by "freezing" a given number of quantities to make the comparison more objective, for example by using identical values for the surface area and the number of habitable rooms, but by using at their actual value the other parameters (structural design, actual number of rooms, number of levels, number of annexes, etc.). This application points out the drawbacks of a financing system in which the price of the habitable square meter is uniform.

Dividing of a Cooperative Building

The presentation of cost results is broken down into five categories:

- the dwelling unit proper
- the private annexes

- the accesses and staircases
- the general elements and equipment
- the "non private"

It is obvious that this break-down corresponds exactly to the needs of speculative builders who have to divide a building amongst several co-owners.

It is even easy to exclude certain rooms (shops, garages) which would be sold separately.

Work Situation Payment

No demonstration is needed to justify the use of the ARC Method in the payment. In particular, the ability to pay the separately makes it possible to most of the rooms located in the lower storeys as soon as they are built by applying unit prices which are graduated in accordance with the kind of room, the condition of completion or the trade concerned. Likewise, the separation of the carcassing from the equipment and the coverings facilitates the assigning of these works to the different trades.

Calculation of Material Quantities

By replacing the unit prices by the quantities of materials used in the work, one obtains very rapidly the total quantity of these materials used, for example, in the construction of a dwelling unit.

This application of the method has been used in particular for calculating the amounts of cement used in different structural designs.

Calculation of Floor Space Spoilt by Vertical Walls

The method immediately gives the length of each type of vertical wall or partition. It is then only necessary to multiply each length by the corresponding thickness to have the floor space occupied by the wall.

Knowing this, is valuable in aiding to calculate the floor surface area of a building or, by using the difference to find out the useful surface areas.

To this day, the ARC Method has already been used in many applications, in particular by engineering offices, architects, contractors and, of course, by the CSTB, where its application has been extended for the comparison of projects in the large tenders initiated by the Ministry of Equipment and Housing. These comparisons in particular make it possible to establish ratios for the different values used which should permit each of these values to be optimized along with the economy of the project as a whole, provided it is possible to act on each parameter separately.

Studies are being conducted to further simplify the application of the method without impairing its accuracy.

APPENDIX E

PLUMBING AGENDA

VISITE DE M. THOMPSON & CHAMPS le 27.XI.1969

- 8h30 Départ du C.S.T.B. ou de l'hôtel Régina de passy
- 9h30 Arrivée à Champs - Présentation des ingénieurs.
- Exposé de M. Chargrasse - objet des travaux.
- 1°) mise au point de méthodes d'essais en vue de la
 normalisation de la qualité des produits.
- 2°) essais de routine
- 3°) recherches en vue d'améliorer le service et l'économie.
- Applications à la plomberie. Appareils sanitaires,
 tuyauteries robinetteries.
- Organisation du service.
- 10h15 Poste d'essai - appareils sanitaires
- qualité des émaux sur céramique, fonte et acier
 méthodes d'essais et classification
 efficacité des cuvettes.
- 11h15 Poste d'essais robinetterie.
- qualité des robinetteries sanitaires: robinets simples,
 robinetteries mélanges, robinets mitigeurs, robinets
 flotteurs, bonde de vidage, siphons: débits, endurance,
 mécanique, résistance mécanique, étanchéité, bruits.
 qualité des revêtements et des joints d'étanchéité.
- 12h15 Déjeuner.
- 13h45 Postes d'essais des tuyauteries
- nature des tubes et tuyaux - classification par emplois
 études sur les assemblages
 applications aux anciennes et aux nouvelles matières
 conditions de pose en fonction de l'emploi
 influence de la température et de la pression.

- 15h30 Poste d'essai hydraulique du bâtiment.
étude des écoulements des eaux usées en vertical et en horizontal
- vidanges des appareils individuelles ou en collecteur
- descente des eaux usées - chute unique
- collecteur général de canalisations
Description des installations réalisées dans le laboratoire vertical. Poste central de commande.
Enregistrement. Exploitation.
- 16h45 Fin de visite.
- 17h Départ pour Paris
- 18h Retour au C.S.T.B.

APPENDIX F
SCHEDULE OF FEES
FOR AGRÉMENT TESTING
NOVEMBER 1969

SCHEDULE OF FEES* FOR AGREEMENT TESTING - NOVEMBER 1969

		<u>AGREEMENT</u>	<u>RENEWAL</u>
1.	HOUSES		
	11. Concrete Houses)		
	12. Wood Houses)	\$ 1,260	\$ 480
	13. Metal Houses)		
2.	LARGE STRUCTURES		
	21. Heavy-Weight)		
	22. Heavy-Weight with)		
	Light-Weight Panels)	\$ 1,260	\$ 480
	23. Light-Weight)		
3.	STRUCTURES AND FRAMEWORK		
	31. Concrete		
	32. Steel	\$ 1,260	\$ 480
	33. Mixed (Steel & Concrete)		
4.	WALLS	\$ 1,260	\$ 480
5.	FLOOR		
	51. Concrete)		
	52. Metal)	\$ 1,440	\$ 600
	53. Miscellaneous)		
6.	LIGHT-WEIGHT PANEL		
	61. Panels (Exterior))		
	62. Filler Elements)	\$ 1,260	\$ 480
	63. Miscellaneous)		
7.	EXTERIOR WOODWORK		
	71. Windows)		
	72. Shutters)	\$ 1,230	\$ 480
	73. Miscellaneous)		

8. ROOFS

81.	Framing and Shell	\$ 1,350	\$ 480
82.	Roofing	1,230	480
83.	Waterproofing	1,230	480
84.	Waterproofing Supports	1,230	480
85.	Complexes	1,350	480
86.	Accessories (Sky lights of Plastics)	1,125	420

9. PARTITION WALLS

91.	Plaster	\$ 1,350	\$ 480
92.	Other types of partitions	1,350	480

10. FLUE PIPE

101.	Flue Tile	1,350	480
102.	Pipe for High-Rise	1,350	480
103.	For Boiler Rooms	1,350	480
104.	Tubing	1,350	480

11. SANITARY PLUMBING

111.	Sanitary Equipment	1,125	420
112.	Piping of Sanitary Partitions	1,350	480
113.	Sanitary Ensembles	1,350	480

12. EQUIPMENT

121.	Electric Heating of Floors	1,125	420
122.	Clothes Drying Closets	1,350	480

13. WALL COATINGS

131.	Interior Plastic Coatings	1,260	480
132.	Exterior Coatings	1,260	480
133.	Coatings	1,260	480
134.	Related Products	1,260	480

14. PRODUCTS RELATED TO PANELS

141.	Mastics for Waterproofing Joints	1,260	480
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15. FLOOR COVERINGS

151.	Plastic	\$ 1,620	600
152.	Textile	1,620	600
153.	Wood	1,350	480
154.	Leveling Coatings	1,260	480
155.	Adhesives for Parquet Floors	1,260	480
156.	Underlayment for Parquet Floors	1,125	420
157.	Adhesives for Floor Tiles (1)	1,260	480
158.	Asphalt	1,260	480

(1) For Supplemental Usage \$ 564

* Based on 5.50 francs per U.S. Dollar. French Lab costs are approximately \$20,000/man year.

SELECTED REFERENCES

1. Delegation Generale a la Recherche Scientifique et Technique, "Scientific and Technical Research in France," Special number 228-229, June-July, 1967 (in English).
2. "La Station de Recherche du Centre Scientifique et Technique du Batiment," Publication describing CSTB facilities, received at NBS July 23, 1969
3. CSTB Organization Chart, November 27, 1969.
4. "L'Industrialisation du Batiment," Librairie Aristide Quillet, 278, Boulevard Saint-Germain, Paris, France, 1959.
5. "Centre Experimental de Recherches et d'etudes du Batiment et des Travaux Publics," publication describing CEBTP laboratory facilities.
6. "CSTB Laboratoire Vertical," layout plan of CSTB plumbing facilities.

All of the selected references as well as numerous other pertinent references are in the BRD files.

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